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ABSTRACT

The state of university science and engineering research capabilities is considered. Attention is directed to the need for improving and enhancing the research infrastructure, including support for instrumentation, buildings, and other related research facilities. U.S. universities and colleges are encountering severe facilities and instrumentation problems. Federal funding to universities has recently been made in political, rather than peer review, circumstances. Recently, several universities have attempted to alleviate their infrastructural problems through direct solicitation to the Congress, thereby by-passing any peer-group review, which is based on scientific merits of specific proposals, in open competition. Constraints to the research infrastructure in U.S. universities include equipment, space, support personnel, graduate student support, and the ability to handle the information explosion and to translate new information into practice. In addition, universities face increased indirect costs. The attractiveness of an academic career is being diminished by an environment that provides outdated equipment and inadequate laboratory space. Tax incentives to business and equipment grants by the federal government are important catalysts in the development of university-industry research partnerships. (SW)

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IMPROVING THE RESEARCH INFRASTRUCTURE AT U.S. UNIVERSITIES AND COLLEGES

ED251035

HEARING

BEFORE THE

COMMITTEE ON SCIENCE AND TECHNOLOGY U.S. HOUSE OF REPRESENTATIVES

NINETY-EIGHTH CONGRESS

SECOND SESSION

MAY 8, 1984

[No. 94]

Printed for the use of the
Committee on Science and Technology

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IMPROVING THE RESEARCH INFRASTRUCTURE AT U.S. UNIVERSITIES AND COLLEGES

TUESDAY, MAY 8, 1984

House of Representatives,
Committee on Science and Technology,
Washington, D.C.

The committee met, pursuant to notice, at 9:12 a.m., in room 2318, Rayburn House Office Building, Hon. Don Fuqua (chairman of the committee) presiding.

Present: Representatives Fuqua, Harkin, Nelson, Lundine, Dymally, Mineta, MacKay, Reid, Sensenbrenner, Skeen, Lowery, Bateman, and McCandless.

Mr. Fuqua. The committee will be in order.

Today's hearing will focus on the state of our university science and engineering research capabilities. In particular, the committee will explore the need for improving and enhancing the research infrastructure, including support for instrumentation, buildings, and other related research facilities.

Before we begin considering this broad topic, I am pleased to announce the beginning of the National Science Foundation's Science Week. This morning's hearing will be followed by a weeklong series of activities, planned by the National Science Foundation, aimed at enhancing public awareness of the importance of science and science education to our Nation's past, present, and future. I congratulate Dr. Edward A. Knapp, Director of the National Science Foundation, for launching such a worthwhile endeavor.

It has come to the committee's attention that our U.S universities and colleges are encountering severe facilities and instrumentation problems. It has been estimated that research instruments used in universities are nearly twice as old as those used in private research labs and in the national laboratories. Also, many universities cannot meet their research facilities needs and, in fact, cannot even afford to maintain and renovate their existing buildings.

In the past, the Federal Government has funded facilities and instrumentation through various agency programs. For example, the National Science Foundation, through the 1960's and the early 1970's, conducted several institutional programs aimed at strengthening research and education in U.S. colleges and universities.

These support programs, totaling nearly $550 million, included the graduate research laboratory development program, aimed at building and renovating university laboratories; institutional grants for science, aimed at generally improving the quality of academic science at universities already receiving NSF awards; and the science development program, aimed at increasing the university centers of excellence.

These successful programs could serve as possible models for future Federal involvement in these areas. In the absence of such programs, the growing unmet need has created a desperate situation for many institutions. Recently, some universities have turned to political lobbying for specific legislation to obtain facilities which normally would go through a more systematic review process. The effect of bypassing this review process could be disruptive. Yet, we must consider the underlying cause of these problems—the declining state of the university research infrastructure.

Our interest today is in delineating the possible avenues of funding support for university research infrastructure and what role the Federal Government should play in that support.

[The opening statement of Mr. Fuqua follows:]

OPENING STATEMENT

HONORABLE DON FUQUA

HEARING ON

"IMPROVING THE RESEARCH INFRASTRUCTURE AT U.S. UNIVERSITIES AND COLLEGES"

MAY 8, 1984

TODAY'S HEARING WILL FOCUS ON THE STATE OF OUR UNIVERSITY SCIENCE AND ENGINEERING RESEARCH CAPABILITIES. IN PARTICULAR, THE COMMITTEE WILL EXPLORE THE NEED FOR IMPROVING AND ENHANCING THE RESEARCH INFRASTRUCTURE, INCLUDING SUPPORT FOR INSTRUMENTATION, BUILDINGS AND OTHER RELATED RESEARCH FACILITIES.

BEFORE WE BEGIN CONSIDERING THIS BROAD TOPIC, I AM PLEASED TO ANNOUNCE THE BEGINNING OF THE NATIONAL SCIENCE FOUNDATION'S SCIENCE WEEK. THIS MORNING'S HEARING WILL BE FOLLOWED BY A WEEK-LONG SERIES OF ACTIVITIES, PLANNED BY THE NATIONAL SCIENCE FOUNDATION, AIMED AT ENHANCING PUBLIC AWARENESS OF THE IMPORTANCE OF SCIENCE AND SCIENCE EDUCATION TO OUR NATION'S PAST, PRESENT, AND FUTURE. I CONGRATULATE DR. EDWARD A. KNAPP, DIRECTOR OF THE NATIONAL SCIENCE FOUNDATION, FOR LAUNCHING SUCH A WORTHWHILE ENDEAVOR.

IT HAS COME TO THE COMMITTEE'S ATTENTION THAT OUR U.S. UNIVERSITIES AND COLLEGES ARE ENCOUNTERING SEVERE FACILITIES AND INSTRUMENTATION PROBLEMS. IT HAS BEEN ESTIMATED THAT RESEARCH INSTRUMENTS USED IN UNIVERSITIES ARE NEARLY TWICE AS OLD AS THOSE USED IN PRIVATE RESEARCH LABS AND IN THE NATIONAL LABORATORIES. ALSO, MANY UNIVERSITIES CANNOT MEET THEIR RESEARCH FACILITIES NEEDS, AND IN FACT, CANNOT EVEN AFFORD TO MAINTAIN AND RENOVATE THEIR EXISTING BUILDINGS.

IN THE PAST, THE FEDERAL GOVERNMENT HAS FUNDED FACILITIES AND INSTRUMENTATION THROUGH VARIOUS AGENCY PROGRAMS. FOR EXAMPLE, THE NATIONAL SCIENCE FOUNDATION, THROUGH THE 1960'S AND THE EARLY 1970'S, CONDUCTED SEVERAL INSTITUTIONAL PROGRAMS AIMED AT STRENGTHENING RESEARCH AND EDUCATION IN U.S. COLLEGES AND UNIVERSITIES.

THESE SUPPORT PROGRAMS, TOTALING NEARLY $550.0 MILLION, INCLUDED: THE GRADUATE RESEARCH LABORATORY DEVELOPMENT PROGRAM, AIMED AT BUILDING AND RENOVATING UNIVERSITY LABORATORIES; INSTITUTIONAL GRANTS FOR SCIENCE, AIMED AT GENERALLY IMPROVING THE QUALITY OF ACADEMIC SCIENCE AT UNIVERSITIRES ALREADY RECEIVING NSF AWARDS; AND, THE SCIENCE DEVELOPMENT PROGRAM, AIMED AT INCREASING THE UNIVERSITY "CENTERS OF EXCELLENCE".

THESE SUCCESSFUL PROGRAMS COULD SERVE AS POSSIBLE MODELS FOR FUTURE FEDERAL INVOLVEMENT IN THIS AREA. IN THE ABSENCE OF SUCH PROGRAMS, THE GROWING UNMET NEED HAS CREATED A DESPERATE SITUATION FOR MANY INSTITUTIONS. RECENTLY, SOME UNIVERSITIES HAVE TURNED TO POLITICAL LOBBYING FOR SPECIFIC LEGISLATION TO OBTAIN FACILITIES WHICH NORMALLY WOULD GO THROUGH A MORE SYSTEMATIC REVIEW PROCESS. THE EFFECT OF BY-PASSING THIS REVIEW PROCESS COULD BE DISRUPTIVE. YET, WE MUST CONSIDER THE UNDER-LYING CAUSE OF THESE PROBLEMS -- THE DECLINING STATE OF THE UNIVERSITY RESEARCH INFRASTRUCTURE.

OUR INTEREST TODAY IS IN DELINEATING THE POSSIBLE AVENUES OF FUNDING SUPPORT FOR UNIVERSITY RESEARCH INFRASTRUCTURE AND WHAT ROLE THE FEDERAL GOVERNMENT SHOULD PLAY IN THAT SUPPORT.

Mr. **Fuqua**. At this time I would like to include for the record a statement from the Honorable Larry Winn, Jr., the ranking minority member.

[The opening statement of Mr. Winn follows:]

OPENING STATEMENT BY THE HONORABLE LARRY WINN, JR.
HEARING ON "IMPROVING THE RESEARCH INFRASTRUCTURE AT U.S. COLLEGES AND UNIVERSITIES"

HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY
MAY 8, 1984

THANK YOU MR. CHAIRMAN FOR THIS OPPORTUNITY TO WELCOME OUR WITNESSES TODAY. WE ARE FORTUNATE TO HAVE THESE EXPERTS HERE AND I AM CERTAIN WE WILL OBTAIN INFORMATION WHICH IS HELPFUL TO US ALL.

IN THE MANY YEARS I HAVE BEEN ASSOCIATED WITH THIS COMMITTEE, I HAVE SEEN STRONG, CONTINUING SUPPORT FOR OUR COLLEGES AND UNIVERSITIES. THEIR VITAL ROLES IN RESEARCH AND DEVELOPMENT HAVE BEEN AND ARE GREATLY APPRECIATED. I DO NOT KNOW HOW WE COULD HAVE SUBSTITUTED ANY OTHER INSTITUTIONS FOR THE EXPERTISE OF OUR COLLEGES AND UNIVERSITIES IN BOTH TRAINING THE ENGINEERS AND SCIENTISTS OF TOMORROW AND IN CONDUCTING BASIC AND APPLIED RESEARCH AND FOLLOW-ON DEVELOPMENT. WE HAVE SEEN MANY OF THESE EDUCATIONAL CENTERS RISE TO THE CHALLENGES OF EXCELLENCE IN EDUCATION AND MOTIVATION. THE COMPETITION AMONG THESE INSTITUTIONS HAS FOSTERED INVENTION, INNOVATION, AND VIGOROUS INITIATIVE.

I THINK MANY OF US WERE QUITE DISAPPOINTED LAST YEAR WHEN WE WERE SUBJECTED TO INSTANCES OF FUNDING UNIVERSITIES WHICH HAVE NOT PARTICIPATED IN THIS COMPETITIVE ENVIRONMENT. I KNOW, FROM CORRESPONDENCE WE HAVE RECEIVED, THAT MANY OTHER COLLEGES AND UNIVERSITIES WERE UPSET THAT AWARDS WOULD BE MADE ON POLITICAL, RATHER THAN PEER REVIEW, CIRCUMSTANCES. HOPEFULLY, WE CAN SET THIS CONDITION

RIGHT BY INTELLIGENT RE-EVALUATION.

IN OUR SUPPORT OF THE AMERICAN COLLEGES AND UNIVERSITIES, WE HAVE MAINTAINED CERTAIN CONCERNS. APPARENTLY, TECHNOLOGY IS MOVING AHEAD SO RAPIDLY THAT OUR INSTITUTIONS ARE UNABLE TO KEEP PACE THROUGH PROVISION OF MODERN INSTRUMENTATION, BUILDINGS, AND SUPPORT FACILITIES. I HAVE HEARD THAT THE COST OF UPDATING THESE NECESSITIES TO INDUSTRIAL LEVELS OF ADEQUACY COULD COST $3 BILLION. AND THAT AMOUNT IS REQUIRED ONLY TO CATCH-UP. POSSIBLY OUR WITNESSES COULD SHED SOME LIGHT ON MEANS TO OVERCOME THIS DILEMMA.

ANOTHER POINT OF CONCERN IS THE HIGH OVERHEAD WHICH IS BEING LEVIED AGAINST RESEARCH PROJECTS BY SOME COLLEGES AND UNIVERSITIES. AGAIN, I AM ADVISED THAT THESE OVERHEAD CHARGES CAN GO AS HIGH AS 80 PERCENT. THAT IS A LARGE AMOUNT TO CHARGE FOR OVERHEAD. WE WONDER WHAT THE DESTINATIONS FOR THESE FUNDS COULD BE. IT WOULD SEEM TO BE HIGHLY IMPRUDENT TO SUPPORT OTHER COURSES OF INSTRUCTION AT THE EXPENSE OF RESEARCH FUNDS. WE INTEND TO EXPLORE THIS CONCERN WITH OUR WITNESSES.

IN CLOSING, MR. CHAIRMAN, I WANT TO EXPRESS AGAIN MY CONTINUED SUPPORT FOR THE INTELLIGENT UTILITIZATION OF THESE VAST RESOURCES AVAILABLE THROUGH THE NATION'S COLLEGES AND UNIVERSITIES. AS ALWAYS, THIS HEARING IS TIMELY AND SHOULD BE BENEFICIAL TO US ALL.

THANK YOU.

Mr. **Fuqua**. I now recognize Mr. Sensenbrenner for any opening statement he may care to make.

Mr. **Sensenbrenner**. Thank you, Mr. Chairman, for this opportunity to welcome our distinguished witnesses to this morning's hearing and to make a few remarks concerning this morning's hearing.

The future of technological innovation, which is determinative of the social and economic vitality of this Nation, is dependent upon this Nation's colleges and universities. This dependency rests upon the dual missions undertaken by our institutions of higher education—research and teaching.

These missions are inextricably linked. University research is a means of inquiry that furthers understanding and whose results are imparted by the investigator to others. Thus, research of necessity requires instruction. Further, although not generally thought of as a product, university research produces the trained talent essential for technological innovation. Conversely, teaching without inquiry diminishes the quality of the instruction. Therefore, in seeking to address the problems of our research infrastructure we must examine and understand the impact of any proposed solutions upon these missions.

Finally, incumbent in any consideration of improving the infrastructure of our colleges and universities is the method by which that is accomplished. Recently there has been an attempt by several universities to alleviate their infrastructural problems through direct solicitation to the Congress, thereby bypassing any peer group review. In response, the American Association of State Colleges and Universities, the American Association of Universities, the National Academy of Sciences, the Association of American Medical Colleges, the American Society for Engineering Education, and the American Physical Society have all issued statements or resolutions, copies of which I have attached to my statement, asking the Congress to reaffirm its support of the peer review process in its funding decisions.

I have, along with the gentleman from Kansas, Mr. Winn, introduced a resolution, House Concurrent Resolution 257, which is cosponsored by members of this committee, in response to their request. Any improvement in the research infrastructure of our universities and colleges must be made on the basis of scientific connections, rather than on having the right connections.

Mr. Chairman, I thank you for holding these hearings and I look forward to our witnesses' testimony concerning these issues. I ask unanimous consent to include in the record the statements I mentioned in my remarks.

Mr. **Fuqua**. Without objection.

[The opening statement of Mr. Sensenbrenner and supporting material follow:]

OPENING STATEMENT OF

HONORABLE F. JAMES SENSENBRENNER, JR., (R-WI)

MAY 8, 1984

THANK YOU, MR. CHAIRMAN, FOR THIS OPPORTUNITY TO WELCOME OUR DISTINGUISHED WITNESSES TO THIS MORNING'S HEARING AND TO MAKE A FEW REMARKS CONCERNING THIS MORNING'S HEARING.

THE FUTURE OF TECHNOLOGICAL INNOVATION, WHICH IS DETERMINATIVE OF THE SOCIAL AND ECONMIC VITALITY OF THIS NATION, IS DEPENDENT UPON THIS NATION'S COLLEGES AND UNIVERSITIES. THIS DEPENDENCY RESTS UPON THE DUAL MISSIONS UNDERTAKEN BY OUR INSTITUTIONS OF HIGHER EDUCATION--RESEARCH AND TEACHING.

THESE MISSIONS ARE INEXTRICABLY LINKED. UNIVERSITY RESEARCH IS A MEANS OF INQUIRY, THAT FURTHERS UNDERSTANDING, AND WHOSE RESULTS ARE IMPARTED, BY THE INVESTIGATOR, TO OTHERS. THUS, RESEARCH, OF NECESSITY, REQUIRES INSTRUCTION. FURTHER, ALTHOUGH NOT GENERALLY THOUGHT OF AS A PRODUCT, UNIVERSITY RESEARCH PRODUCES THE TRAINED TALENT ESSENTIAL FOR TECHNOLOGICAL INNOVATION. CONVERSELY, TEACHING WITHOUT INQUIRY DIMINISHES THE

QUALITY OF THE INSTRUCTION. THEREFORE, IN SEEKING TO ADDRESS THE PROBLEMS OF OUR RESEARCH INFRASTRUCTURE, WE MUST EXAMINE AND UNDERSTAND THE IMPACT OF ANY PROPOSED SOLUTIONS UPON THESE MISSIONS.

FINALLY, INCUMBENT IN ANY CONSIDERATION OF IMPROVING THE INFRASTRUCTURE OF OUR COLLEGES AND UNIVERSITIES, IS THE METHOD BY WHICH THAT IS ACCOMPLISHED. RECENTLY, THERE HAS BEEN AN ATTEMPT BY SEVERAL UNIVERSITIES TO ALIEVATE THEIR INFRASTRUCTURAL PROBLEMS THOUGH DIRECT SOLICITATION TO THE CONGESS, THEREBY BY-PASSING ANY PEER-GROUP REVIEW. IN RESPONSE, THE AMERICAN ASSOCIATION OF STATE COLLEGES AND UNIVERSITIES, THE AMERICAN ASSOCIATION OF UNIVERSITIES, THE NATIONAL ACADEMY OF SCIENCES, THE ASSOCIATION OF AMERICAN MEDICAL COLLEGES, THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION, AND THE AMERICAN PHYSICAL SOCIETY, HAVE ALL ISSUED STATEMENTS OR RESOLUTIONS, COPIES OF WHICH I HAVE ATTACHED TO MY STATEMENT, ASKING THE CONGRESS TO REAFFIRM ITS SUPPORT OF THE PEER REVIEW PROCESS IN ITS FUNDING DECISIONS. I HAVE, ALONG WITH THE GENTLEMAN FROM KANSAS, MR. WINN, INTRODUCED A RESOLUTION, H. CON. RES. 257, WHICH IS COSPONSORED BY MEMBERS OF THIS COMMITTEE, IN RESPONSE TO THEIR REQUEST. ANY IMPROVEMENT IN THE RESEARCH INFRASTRUCTURE OF OUR UNIVERSITIES AND COLLEGES MUST BE MADE ON THE BASIS OF SCIENTIFIC MERIT, RATHER THAN ON HAVING THE RIGHT CONNECTIONS.

MR. CHAIRMAN, I THANK YOU FOR HOLDING THESE HEARINGS AND I LOOK FORWARD TO OUR WITNESSES' TESTIMONY CONCERNING THESE ISSUES.

NATIONAL ACADEMY OF SCIENCES
2101 Constitution Avenue Washington D C 20418

STATEMENT OF THE COUNCIL

FEDERAL FUNDING FOR RESEARCH FACILITIES AND INSTRUMENTATION

In recent months, there have been a few instances in which federal funding decisions for major university scientific facilities have not been subject to an appropriate review process. Informed peer judgments on the scientific merits of specific proposals, in open competition, should be a central element in the awarding of all federal funds for science.

In the past, such objective systems of evaluation have met the needs of our country well, and have contributed to the scientific preeminence of the United States. In the long term, they also help to maintain the pluralism that is important to the productivity of American science and is characteristic of political decision making.

We urge that the academic community and public officials exercise vigilance to protect this informed evaluation and decision-making process in the awarding of funds, not only for the support of scientific research proposals, but also for major scientific facilities and instrumentation.

October 30, 1983

The American Physical Society
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October 24, 1983

Hon. J.J. Sensenbrenner Jr.
U.S. House of Representatives
Washington D.C. 20515

Dear Mr. Sensenbrenner:

As President of the American Physical Society I wish to express my deep concern over the authorization of funds for major scientific projects in the absence of informed advice from impartial scientific experts. My concern is shared by the entire Executive Committee of the Society and, I am confident, by the overwhelming majority of the 33,000 rank and file members of the Society.

Specifically, our concern arises from the inclusion in HR 3132 of funds for the creation of a Vitreous State Laboratory at Catholic University and a National Chemical Research Center at Columbia University. These projects were introduced by floor amendment without consideration in the Authorization Committee. Although both projects were eliminated by the Senate, they were subsequently restored in the final appropriation bill (Conference Report 98-272), subject to the restriction that funds not be obligated for these two projects until they have been subjected to a technical review and approval by the Department of Energy. Such a review is not, in our opinion, a satisfactory substitute for established procedures of submission and review by the appropriate agency followed by debate in the Authorization Committee.

In a related issue, the DoE proposed a program to create a National Center for Advanced Materials (NCAM) at Berkeley. The program was eliminated by the House on the grounds of inadequate review, but partially restored by the Senate, on the condition that adequate technological review be made before funds are available. Although the Center, as proposed, is to become the largest single facility in the U.S. to undertake basic research in materials. here again the established procedures of submission and review were bypassed.

Each year many worthy scientific projects are abandoned or deferred for lack of funds. Each such instance represents, to some degree, a technological risk for the United States. It is therefore essential that the advice of our leading experts be sought on establishing priorities, to insure that the most essential and promising projects are funded. Failure to follow such procedure leads invariably to a widespread perception that success in the competition for federal research funds is less dependent on scientific merit than on having the right connections. In our opinion, confidence in the system has been seriously shaken by these instances and will be restored only by rigorous adherence to the established procedures in all future scientific funding.

We feel that it is important that this recent trend toward special interest funding of major scientific projects be reversed and urge your support on insuring that all major scientific proposals adhere to established procedures of submission and review.

Sincerely yours,

Robert E. Marshak

Robert E. Marshak

REM:mc

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AAU STATEMENT ON DECISION MAKING IN FEDERAL FUNDING FOR RESEARCH FACILITIES

The Association of American Universities represents institutions whose faculties are deeply engaged in research. We share with many other institutions and individuals a commitment to advancing the quality of the nation's research effort. Since the vitality of this effort is closely linked to the soundness of decisions made about science by public bodies, it is both appropriate and important for the AAU to state its collective views about the ways in which those decisions are best made.

The United States has evolved an admirable but fragile system of awarding federal funds for research. In general, Congress appropriates funds for the support of broad categories of research. Subsequently, the administering federal agency issues guidelines for making applications in a manner that assures fair and open competition. Researchers then submit detailed proposals that are judged by experts, scientists chosen for their ability to make sound and careful judgments in the scientific area involved. This method maximizes the scientific return on the federal investment by assuring that awards are made on the scientific merit of the proposal and the professional merit of the proposer.

The same method governed most federal programs in support of scientific facilities when such programs existed. However, in the early 1970s, most federal government programs in support of the construction and renovation of research facilites ended. The subsequent decade-long failure to attend to the capital base of university science has led to a backlog of need that has hampered American science and placed great stress on the processes by which the government allocates scientific resources.

We believe that processes based on the informed peer judgments of other scientists need to be preserved and strengthened. We therefore urge scientists, leaders of America's universities, and Members of Congress to support the practice of awarding funds for the support of science on the basis of scientific merit, judged in an objective and informed manner. Further, we urge them to refrain from actions that would make scientific decisions a test of political influence rather than a judgment on the quality of the work to be done. These principles should apply in making decisions about scientific facilities as well as in awarding funds for research projects.

Finally, we urge officials of the national Administration and Members of Congress to deal promptly with the decay of the physical plant that houses much of the nation's basic research. S.1537, introduced by Senators Danforth and Eagleton, is a bipartisan effort to deal with this national priority and deserves strong and prompt support.

October 25, 1983

NAME OF COMMITTEE: Committee on Science and Technology
CHAIR OF COMMITTEE: John Wright
NAME OF PRESENTER: John Wright
DATE: November 22, 1983 RESOLUTION #13

WHEREAS, The 358 member institutions of the American Association of State Colleges and Universities (AASCU) are committed to fostering scientific research beneficial to our nation,

WHEREAS, Federal funds for research projects and facilities are traditionally awarded on the basis of their scientific merit judged in a fair and open competition,

WHEREAS, An equitable process of peer review at Federal agencies must be the guiding force in the awarding of funds for new scientific facilities and research projects,

WHEREAS, Recent efforts by some institutions have bypassed this preferred peer review process,

WHEREAS, Other scientific and educational associations have urged the reversal of these recent actions and an adherence to peer review procedures in all future scientific funding, be it

RESOLVED, That the American Association of State Colleges and Universities (AASCU) join with these other groups in reaffirming the principle that funds for the support of science be awarded on the basis of "scientific merit, judged in an objective and informed manner" by a panel of peers, and be it further

RESOLVED, That we urge scientists, educators and members of Congress to "refrain from actions that would make scientific decisions a test of political influence rather than a judgment of the quality of the work to be done." *

* AAU Statement on Decision Making in Federal Funding for Research Facilities, October 25, 1983.

American Society
for
Engineering Education

washington, d.c.

REPLY TO

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Colorado State University

RESOLUTION

At the annual meeting of the Engineering Deans' Institute on April 4, 1984, the following action was taken:

WHEREAS, The Engineering Deans' Council of ASEE are commitied to fostering fundamental engineering research and engineering education beneficial to our nation,

WHEREAS, Federal funds for research projects and facilities are traditionally awarded on the basis of their merit judged in a fair and open competition,

WHEREAS, An equitable process of peer review at Federal agencies must be the guiding force in the awarding of funds for new engineering facilities and research projects,

WHEREAS, Recent efforts by some institutions have bypassed this preferred peer review process,

WHEREAS, Other scientific and educational associations have urged the reversal of these recent actions and an adherence to peer review procedures in all future engineering and scientific funding, be it

RESOLVED, That the Engineering Deans' Council of ASEE join with these other groups in reaffirming the principle that funds for the support of engineering and science be awarded on the basis of "merit, judged in an objective and informed manner" by a panel of peers, and be it further

RESOLVED, That we urge engineers, scientists, educators and members of Congress to "refrain from actions that would base the awarding of Federally funded research and education facilities on political influence rather than on the merit of the work to be done."

American Association
for the Advancement of Science

1776 MASSACHUSETTS AVENUE, NW, WASHINGTON, D. C., 20036

Phone: 467-4400 (Area Code 202) Cable Address: Advancesci, Washington, D. C.

March 1, 1984

The Honorable F. James Sensenbrenner
315 Cannon House Office Building
U.S. House of Representatives
Washington, D.C. 20515

Dear Mr. Sensenbrenner:

Thank you for your letter of February 15 about H. Con. Res. 257 which you have introduced along with Larry Winn.

I would hope that the calendar of the House Science and Technology Committee will permit an early consideration of 257. An upcoming AAAS Board meeting on 9-10 March will include an overview of various congressional activities. At that time I will review with Board members the action you and Mr. Winn have taken in response to the Board's statement on 10 December 1984.

In the event the Committee chooses to hold hearings on the Resolution, the American Association for the Advancement of Science stands prepared to testify in support of it, if we are asked to do so. You and Mr. Winn are to be complimented on your prompt and direct response to the potential problems outlined in our December statement.

Sincerely,

William D. Carey

William D. Carey
Executive Officer

IV

98TH CONGRESS
2D SESSION

H. CON. RES. 257

To reaffirm the commitment of the Congress to award Federal funds for scientific research projects and facilities solely on the basis of scientific merit as determined by a peer review process.

IN THE HOUSE OF REPRESENTATIVES

FEBRUARY 8, 1984

Mr. SENSENBRENNER (for himself and Mr. WINN) submitted the following concurrent resolution; which was referred to the Committee on Science and Technology

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CONCURRENT RESOLUTION

To reaffirm the commitment of the Congress to award Federal funds for scientific research projects and facilities solely on the basis of scientific merit as determined by a peer review process.

Whereas the Congress is committed to fostering scientific research beneficial to our Nation;

Whereas this commitment has enabled the United States to achieve preeminence in scientific research;

Whereas this preeminence can be maintained only when Federal funds for scientific research projects and facilities are awarded solely on the basis of scientific merit as determined by peer review groups;

Whereas peer review at Federal agencies must be the touchstone for awarding Federal funds for scientific research projects and facilities;

Whereas recent incidents of political influence by some institutions have bypassed this preferred peer review process and threaten the Congress commitment of unbiased support for meritorious scientific research projects and facilities; and

Whereas scientific and educational associations have urged the Congress to reaffirm its commitment to adhere to peer review procedures in funding scientific research projects and facilities: Now, therefore, be it

Resolved by the House of Representatives (the Senate concurring), That the Congress reaffirms its commitment to the principle that funds for the support of scientific research projects and facilities should be awarded solely on the basis of scientific merit as determined in a fair and open competition by a review of peers, and urges that interested parties refrain from actions that would bypass the peer review process.

Mr. FUQUA. Permission is granted to take pictures throughout the course of the hearing.

Today our first witness to present his remarks is Dr. George Keyworth, Science Adviser to the President and Director of the Office of Science and Technology Policy. I am pleased to welcome Dr. Keyworth.

Dr. Keyworth, you may present your prepared statement and we will make it a part of the record, if you wish, or you may summarize your remarks.

STATEMENT OF DR. GEORGE A. KEYWORTH, SCIENCE ADVISER TO THE PRESIDENT AND DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY, EXECUTIVE OFFICE OF THE PRESIDENT

Dr. KEYWORTH. Mr. Chairman and members of the committee, I'm particularly pleased to have a chance to meet with you today. The subject of these hearings, which might be characterized as the health of our universities and colleges, occupies a very high priority in the White House Science Office. The competition that our country faces from foreign competitors, both in the area of industry and national security, can only be met by taking full advantage of the immense science and technology expertise we have in the United States. In order to do that we depend on the continuing production of highly trained technical personnel from our Nation's universities and colleges.

American universities are clearly one of the most precious resources this country has. Although there are individual great universities in many countries, as a group the U.S. universities far, far outdistance those of any other nation. The model we've evolved over the past century—of close interaction between research and education—not only allows our classroom instruction to reflect the most current information possible, but it also means that we can expose our students to some of the most creative minds in the world in the form of their teachers.

Mr. Chairman, there can be no disagreement that the public interest requires a healthy and stimulating atmosphere for both research and education in our universities and colleges. This is a responsibility that cuts across all of society, because all of society benefits from healthy universities. As you know, Federal programs, State and local government efforts, and industrial initiatives, both separately and in growing partnerships, have gone a long way over the past few years in strengthening those areas of university research and training with the greatest potential for contributing to our needs. As a result, the situation today is significantly better than it was just a short time ago, and programs now underway will continue to bring improvements in the future, so now, with those substantial programs underway, I believe this is a good time for us to assess the future.

One extremely hopeful sign is the progress we've been making in overcoming what had evolved in recent years to become an adversarial rather than cooperative relationship between industry, academia, and Government. Admittedly, we still have a long way to go in repairing this relationship, but the payoffs are worth the effort.

And by payoffs I mean our ability to capture this great advantage we have over our competitors—and that's the clear superiority of American science and technology.

I would offer as evidence of this superiority the remarkable continuing record of success of American scientists in winning Nobel Prizes in science—a clean sweep last year and more than 70 percent of all the science prizes of the past decade. Our leadership in science offers us great leverage, great opportunities to devise innovative new technologies and applications of technology. But to continue to capitalize on this leverage, in today's economic environment we need to strengthen even more the partnerships between the different sectors of America. These are the partnerships we need if we expect to remain truly competitive with other nations, if we expect to keep America No. 1.

This challenge weighs heavily on the administration and the Congress because of the inevitable influence that Federal actions have on universities. As we've seen, Federal actions can lead universities to incur substantial financial obligations they might otherwise have avoided. In fact, those schools with large research programs, many of which have their origins in Federal programs, also have much higher ongoing expenses just to maintain their infrastructure.

Today, universities conduct more basic research than any other institutions in our society, so we can see why Federal funding for basic research is a commonly used measure of the Federal Government's support for the university research infrastructure. And, as I pointed out several months ago to this committee, with the President's fiscal 1985 budget request we're looking at a real increase beyond mere inflation of more than 25 percent over the past 4 years in Federal support for basic research in universities and colleges.

In truth, we don't yet know what the extent of the impact of those increases will be because a substantial part of it is still in the pipeline. Those are the funds for new fiscal year 1984 programs and for fiscal year 1985 programs that won't be fully implemented for another year, so one of my messages over the past 2 years to universities has been for them to be patient because help is on the way.

Mr. Chairman, like you I've had numerous opportunities to discuss this problem with university presidents and administrators. In almost all cases they point back to the 1960's as the golden years of university health. In those post-Sputnik years the Nation placed an unprecedented emphasis on science and technology and on the training of technical talent in particular.

Well, golden ages are golden because they are rare. Today, and for the foreseeable future, we have to anticipate many more constraints on our ability to support rapid growth across all sectors of society. Our universities and colleges, along with everyone else, now have to adjust to an era of more limited resources. That doesn't mean the universities can't be very healthy but it means they and we have to set priorities for support.

Mr. Chairman, I would like to make what I think is an important observation about that support. In the 1960's, before the inhibiting effect of the Mansfield amendment, the strongest and in many ways most imaginative supporter of university basic research was the Department of Defense and very little of this was classified research or, frankly, research with any direct military application, but in those days the DOD recognized the value of a solid investment in knowledge and in talent.

Although the formal restrictions of the Mansfield amendment no longer exist, they did their damage. We have lost much of the all-important commitment and expertise within DOD that made its program so successful. This is an issue that I have discussed with Secretary Weinberger and with Under Secretary DeLauer. Both of them recognize the responsibility of DOD to once again play a strong role in helping our universities, and they have expressed their commitment to trying to bring that about. My point is that DOD can and should play a significant role in maintaining university health.

Of course, it wasn't only DOD that was emphasizing mission relevance in its R&D support in the seventies. Civilian agencies drew back on their investments in basic research, too. The universities, in a financial bind, did what you or I would probably choose to do. In order to support researchers and students, they cut other expenditures. That meant deferring improvements to facilities, deferring purchase and even maintenance of instrumentation, and in general conserving programs they had rather than undertaking new ones. So in a very real sense the economizing actions they had to take in the seventies when basic research support fell off led to some of the problems we see today.

The resulting deterioration of research instrumentation at U.S. universities and colleges has been the subject of a number of studies. This instrumentation problem has many causes, not the least of which is the pace of today's technological progress, which quickly renders scientific instrumentation obsolete. For that reason, we have to recognize it not only as an acute problem today but as a continuing problem from now on, but we should also be aware that this is a situation in which industry can provide significant assistance, particularly if universities are encouraged and permitted to explore new methods for financing the purchase and lease of instruments. We should certainly try to continue to search for ways to stimulate university-industry cooperation to address these needs.

At the same time, the administration has already proposed substantial increases in funding for instrumentation over the past few years. In fiscal years 1984 and 1985 we expect a total of more than $800 million in Federal funds to be applied to high-priority instrumentation needs in universities. This emphasis over a period of years should greatly reduce this problem of inadequate instrumentation.

Aging research facilities—and by that we mean laboratories and large research tools—constitute a different kind of problem which is more difficult to solve. Funds for new laboratories are hard to find, and universities are particularly strapped for funds to maintain and now renovate aging facilities. At this point it is very hard to get a good idea of just what the needs are. An ad hoc interagency steering committee was formed by NSF in November of 1983 to conduct an indepth study of the university research facilities. We expect some results from this study by February of next year.

The problems of research instrumentation and facilities are only two facets of the broader concern regarding the health of U.S. colleges and universities. The real question is whether these institutions will be able to continue to produce the leading scientists and engineers that the country will need to compete. I think we have taken some major steps to turn around this problem of the research infrastructure in our universities and colleges. Specifically, the strong growth in Federal support for university research, the emphasis on instrumentation, the special programs to improve the linkages between industry and academia, all constitute important changes over the past few years.

Mr. Chairman, although there has been a de facto relationship between universities and the Federal Government for more than 40 years, there has been no explicit recognition of the nature of this relationship nor of the responsibility of the Federal Government toward universities, so I think it is time for Government to take a fresh look at whether there could be more productive relationships between mission agencies and universities, relationships that acknowledge the unique role of universities in producing both research and talent.

For that reason, I have recently asked the White House Science Council to undertake a study of the broad policy questions that affect the current and future health of our colleges and universities. Let me just suggest some of the topics that I hope they will look at.

One would be the issue of the Federal Government's role in ensuring a productive research environment. This includes the nagging problem of indirect costs, an issue that Secretary Heckler has specifically asked us to address. In response to her request, an OSTP staff working group has been established, and their work will be coordinated with that of the Science Council.

A second area of the study is likely to concern the effects on research productivity of the uncertainties and redtape involved in funding. While we have no intention of even suggesting an entitlement program for research, neither do we see much sense in forcing the most productive researchers and teachers to waste so much of their time playing the grantsmanship games.

Some possibilities have been suggested and should be looked at. They include multiyear funding cycles in the Congress; longer term project grants from the agencies; large flexible grants to institutions instead of individual project grants; even research support for outstanding individuals based on a history of performance rather than on a research proposal.

I would expect the group also to look at the problem I discussed earlier, that of the university physical facilities and instrumentation. Another question worth a fresh look is whether mission agencies have special responsibilities, of the kind that NSF does, to help maintain the health of universities, and just how broad are those responsibilities.

Since I know the White House Science Council members recognize the tremendous importance to U.S. university vitality of foreign students and teachers, I would hope the group would consider positive ways to encourage and retain them in this country—as opposed to that sentiment that would limit the access of the best foreign intellects to our universities.

Finally, over the past few years a new factor has emerged in universities—their increased interactions with industry. How do we maximize the benefits to universities of this interaction and how do we minimize the risks of compromising the research environment we are determined to enhance? I am especially pleased with the prospects for this study, and I would expect that its outcome will play an important part in the approaches we propose to take in coming years.

Mr. Chairman, that concludes my testimony. I would, of course, be pleased to respond to questions from members of the committee.

[The prepared statement of Dr. Keyworth follows:]

PROPOSED TESTIMONY OF DR. G. A. KEYWORTH, II
SCIENCE ADVISOR TO THE PRESIDENT, AND
DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY
EXECUTIVE OFFICE OF THE PRESIDENT

HEARINGS ON IMPROVING THE RESEARCH INFRASTRUCTURE
AT U.S. UNIVERSITIES AND COLLEGES

UNITED STATES HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE AND TECHNOLOGY

MAY 8, 1984

MR. CHAIRMAN AND MEMBERS OF THE COMMITTEE:

I'M PARTICULARLY PLEASED TO HAVE A CHANCE TO MEET WITH YOU TODAY. THE SUBJECT OF THESE HEARINGS, WHICH MIGHT BE CHARACTERIZED AS THE HEALTH OF OUR UNIVERSITIES AND COLLEGES, OCCUPIES A VERY HIGH PRIORITY IN THE WHITE HOUSE SCIENCE OFFICE. THE COMPETITION THAT OUR COUNTRY FACES FROM FOREIGN COMPETITORS, BOTH IN THE AREA OF INDUSTRY AND NATIONAL SECURITY, CAN ONLY BE MET BY TAKING FULL ADVANTAGE OF THE IMMENSE SCIENCE AND TECHNOLOGY EXPERTISE WE HAVE IN THE UNITED STATES. AND IN ORDER TO DO THAT WE DEPEND ON THE CONTINUING PRODUCTION OF HIGHLY TRAINED TECHNICAL PERSONNEL FROM OUR NATION'S UNIVERSITIES AND COLLEGES.

AMERICAN UNIVERSITIES ARE CLEARLY ONE OF THE MOST PRECIOUS RESOURCES THIS COUNTRY HAS. ALTHOUGH THERE ARE INDIVIDUAL GREAT UNIVERSITIES IN MANY COUNTRIES, AS A GROUP THE U.S. UNIVERSITIES FAR, FAR OUTDISTANCE

THOSE OF ANY OTHER NATION. THE MODEL WE'VE EVOLVED OVER THE PAST CENTURY--OF CLOSE INTERACTION BETWEEN RESEARCH AND EDUCATION--NOT ONLY ALLOWS OUR CLASSROOM INSTRUCTION TO REFLECT THE MOST CURRENT INFORMATION POSSIBLE, BUT IT ALSO MEANS THAT WE CAN EXPOSE OUR STUDENTS TO SOME OF THE MOST CREATIVE MINDS IN THE WORLD IN THE FORM OF THEIR TEACHERS.

MR. CHAIRMAN, THERE CAN BE NO DISAGREEMENT THAT THE PUBLIC INTEREST REQUIRES A HEALTHY AND STIMULATING ATMOSPHERE FOR BOTH RESEARCH AND EDUCATION IN OUR UNIVERSITIES AND COLLEGES. THIS IS A RESPONSIBILITY THAT CUTS ACROSS ALL OF SOCIETY, BECAUSE ALL OF SOCIETY BENEFITS FROM HEALTHY UNIVERSITIES. AS YOU KNOW, FEDERAL PROGRAMS, STATE AND LOCAL GOVERNMENT EFFORTS, AND INDUSTRIAL INITIATIVES, BOTH SEPARATELY AND IN GROWING PARTNERSHIPS, HAVE GONE A LONG WAY OVER THE PAST FEW YEARS IN STRENGTHENING THOSE AREAS OF UNIVERSITY RESEARCH AND TRAINING WITH THE GREATEST POTENTIAL FOR CONTRIBUTING TO OUR NEEDS. AS A RESULT, THE SITUATION TODAY IS SIGNIFICANTLY BETTER THAN IT WAS JUST A SHORT TIME AGO, AND PROGRAMS NOW UNDERWAY WILL CONTINUE TO BRING IMPROVEMENTS IN THE FUTURE. SO NOW, WITH THOSE SUBSTANTIAL PROGRAMS UNDERWAY, I BELIEVE THIS IS A GOOD TIME FOR US TO ASSESS THE FUTURE.

ONE EXTREMELY HOPEFUL SIGN IS THE PROGRESS WE'VE BEEN MAKING IN OVERCOMING WHAT HAD EVOLVED IN RECENT YEARS TO BECOME AN ADVERSARIAL RATHER THAN COOPERATIVE RELATIONSHIP BETWEEN INDUSTRY, ACADEMIA, AND GOVERNMENT. ADMITTEDLY, WE STILL HAVE A LONG WAY TO GO IN REPAIRING THIS RELATIONSHIP, BUT THE PAYOFFS ARE WORTH THE EFFORT. AND BY PAYOFFS I MEAN OUR ABILITY TO CAPTURE THIS GREAT ADVANTAGE WE HAVE OVER OUR COMPETITORS--AND THAT'S THE CLEAR SUPERIORITY OF AMERICAN SCIENCE AND TECHNOLOGY.

I WOULD OFFER AS EVIDENCE OF THIS SUPERIORITY THE REMARKABLE CONTINUING RECORD OF SUCCESS OF AMERICAN SCIENTISTS IN WINNING NOBEL PRIZES IN SCIENCE--A CLEAN SWEEP LAST YEAR AND MORE THAN 70 PERCENT OF ALL THE SCIENCE PRIZES OVER THE PAST DECADE. OUR LEADERSHIP IN SCIENCE OFFERS US GREAT LEVERAGE, GREAT OPPORTUNITIES TO DEVISE INNOVATIVE NEW TECHNOLOGIES AND APPLICATIONS OF TECHNOLOGY. BUT TO CONTINUE TO CAPITALIZE ON THIS LEVERAGE, IN TODAY'S ECONOMIC ENVIRONMENT WE NEED TO STRENGTHEN EVEN MORE THE PARTNERSHIPS BETWEEN THE DIFFERENT SECTORS OF AMERICA. THESE ARE THE PARTNERSHIPS WE NEED IF WE EXPECT TO REMAIN TRULY COMPETITIVE WITH OTHER NATIONS, IF WE EXPECT TO KEEP AMERICA NUMBER ONE.

THIS CHALLENGE WEIGHS HEAVILY ON THE ADMINISTRATION AND THE CONGRESS BECAUSE OF THE INEVITABLE INFLUENCE

THAT FEDERAL ACTIONS HAVE ON UNIVERSITIES. AS WE'VE SEEN, FEDERAL ACTIONS CAN LEAD UNIVERSITIES TO INCUR SUBSTANTIAL FINANCIAL OBLIGATIONS THEY MIGHT OTHERWISE HAVE AVOIDED. IN FACT, THOSE SCHOOLS WITH LARGE RESEARCH PROGRAMS, MANY OF WHICH HAVE THEIR ORIGINS IN FEDERAL PROGRAMS, ALSO HAVE MUCH HIGHER ONGOING EXPENSES JUST TO MAINTAIN THEIR INFRASTRUCTURE.

TODAY, UNIVERSITIES CONDUCT MORE BASIC RESEARCH THAN ANY OTHER INSTITUTIONS IN OUR SOCIETY, SO WE CAN SEE WHY FEDERAL FUNDING FOR BASIC RESEARCH IS A COMMONLY USED MEASURE OF THE FEDERAL GOVERNMENT'S SUPPORT FOR THE UNIVERSITY RESEARCH INFRASTRUCTURE. AND AS I POINTED OUT SEVERAL MONTHS AGO TO THIS COMMITTEE--WITH THE PRESIDENT'S FY 1985 BUDGET REQUEST WE'RE LOOKING AT A REAL INCREASE, BEYOND MERE INFLATION, OF MORE THAN 25 PERCENT OVER THE PAST FOUR YEARS IN FEDERAL SUPPORT FOR BASIC RESEARCH IN UNIVERSITIES AND COLLEGES.

IN TRUTH, WE DON'T YET KNOW WHAT THE EXTENT OF THE IMPACT OF THOSE INCREASES WILL BE, BECAUSE A SUBSTANTIAL PART OF IT IS STILL IN THE PIPELINE. THOSE ARE THE FUNDS FOR NEW FY 84 PROGRAMS AND FOR FY 85 PROGRAMS THAT WON'T BE FULLY IMPLEMENTED FOR ANOTHER YEAR. SO ONE OF MY MESSAGES OVER THE PAST TWO YEARS TO UNIVERSITIES HAS BEEN FOR THEM TO BE PATIENT--BECAUSE HELP IS ON THE WAY.

THERE'S NO QUESTION BUT THAT UNIVERSITIES HAVE HAD THEIR SHARE OF UPS AND DOWNS OVER THE PAST FOUR DECADES. NOT ONLY HAVE THEY SEEN SWINGS IN THE NATURE AND AMOUNT OF SUPPORT FOR THEIR RESEARCH PROGRAMS, BUT DEMOGRAPHIC CYCLES HAVE SOMETIMES SEVERELY PRESSURED THEIR RESOURCES. SOMETIMES UNIVERSITIES HAVE HAD TO MOUNT MAD RUSHES TO DEVELOP NEW PROGRAMS AND BUILD ADDITIONAL FACILITIES TO ACCOMODATE GROWING STUDENT POPULATIONS, AND LATER, AS STUDENT POPULATIONS AND INTERESTS CHANGED, THEY FOUND THEIR FLEXIBILITY OF RESPONSE SEVERELY LIMITED BY COMMITMENTS MADE IN EARLIER TIMES.

MR. CHAIRMAN, LIKE YOU I'VE HAD NUMEROUS OPPORTUNITIES TO DISCUSS THIS PROBLEM WITH UNIVERSITY PRESIDENTS AND ADMINISTRATORS. IN ALMOST ALL CASES THEY POINT BACK TO THE 1960'S AS THE GOLDEN YEARS OF UNIVERSITY HEALTH. IN THOSE POST-SPUTNIK YEARS THE NATION PLACED AN UNPRECEDENTED EMPHASIS ON SCIENCE AND TECHNOLOGY, AND ON THE TRAINING OF TECHNICAL TALENT IN PARTICULAR. THIS EMPHASIS MEANT INCREASED INTEREST AND SUPPORT FROM ALL SECTORS, INCLUDING A RECOGNITION OF A STRONG FEDERAL GOVERNMENT ROLE.

WELL, GOLDEN AGES ARE GOLDEN BECAUSE THEY'RE RARE. TODAY, AND FOR THE FORESEEABLE FUTURE, WE HAVE TO ANTICIPATE MANY MORE CONSTRAINTS ON OUR ABILITY TO SUPPORT RAPID GROWTH ACROSS ALL SECTORS OF SOCIETY. OUR UNIVERSITIES AND COLLEGES, ALONG WITH EVERYONE ELSE, NOW HAVE TO ADJUST TO AN ERA OF MORE LIMITED RESOURCES. THAT DOESN'T MEAN THE UNIVERSITIES CAN'T BE VERY HEALTHY, BUT IT MEANS THEY AND WE HAVE TO SET PRIORITIES FOR SUPPORT.

MR. CHAIRMAN, I'D LIKE TO MAKE WHAT I THINK IS AN IMPORTANT OBSERVATION ABOUT THAT SUPPORT. IN THE 1960S, BEFORE THE INHIBITING EFFECT OF THE MANSFIELD AMENDMENT, THE STRONGEST AND IN MANY WAYS MOST IMAGINATIVE SUPPORTER OF UNIVERSITY BASIC RESEARCH WAS THE DEPARTMENT OF DEFENSE. AND VERY LITTLE OF THIS WAS CLASSIFIED RESEARCH, OR, FRANKLY, RESEARCH WITH ANY DIRECT MILITARY APPLICATION. BUT IN THOSE DAYS THE DOD RECOGNIZED THE VALUE OF A SOLID INVESTMENT IN KNOWLEDGE AND TALENT.

IF THAT OBJECTIVE SOUNDS FAMILIAR TO YOU, IT'S BECAUSE OUR ADMINISTRATION HAS BEEN STRESSING THOSE SAME GOALS FOR MUCH OF OUR SUPPORT FOR BASIC RESEARCH TODAY. THE FACT IS THAT MANY OF THE NATION'S BEST RESEARCH UNIVERSITIES--PLACES LIKE MIT AND CALTECH--ARE STRONG NATIONAL RESOURCES TODAY PRECISELY AS A RESULT OF THAT DOD SUPPORT TWO DECADES AGO. WE'VE DONE OURSELVES A GRAVE DISSERVICE IN THE FIFTEEN YEARS SINCE WE REINED IN THE ABILITY OF DOD TO SUPPORT BROAD AREAS OF RESEARCH AND EDUCATION.

ALTHOUGH THE FORMAL RESTRICTIONS OF THE MANSFIELD AMENDMENT NO LONGER EXIST, THEY DID THEIR DAMAGE. WE'VE LOST MUCH OF THE ALL-IMPORTANT COMMITMENT AND EXPERTISE WITHIN DOD THAT MADE ITS PROGRAMS SO SUCCESSFUL. THIS IS AN ISSUE I'VE DISCUSSED WITH SECRETARY WEINBERGER AND WITH UNDERSECRETARY DELAUER. BOTH OF THEM RECOGNIZE THE RESPONSIBILITY OF DOD TO ONCE AGAIN PLAY A STRONG ROLE IN HELPING OUR UNIVERSITIES--AND THEY'VE EXPRESSED THEIR COMMITMENT TO TRYING TO BRING THAT ABOUT. IN THE PAST FEW YEARS WE'VE BEGUN TO MAKE SOME SLOW PROGRESS IN REBUILDING DOD'S UNIVERSITY PROGRAMS, AND I THINK WE CAN EXPECT TO SEE GROWTH IN THAT AREA IN THE NEXT FEW YEARS. MY POINT IS THAT DOD CAN AND SHOULD PLAY A SIGNIFICANT ROLE IN MAINTAINING UNIVERSITY HEALTH.

OF COURSE, IT WASN'T ONLY DOD THAT WAS EMPHASIZING "MISSION-RELEVANCE" IN ITS R&D SUPPORT IN THE 1970'S. CIVILIAN AGENCIES DREW BACK ON THEIR INVESTMENTS IN BASIC RESEARCH TOO. FEDERAL EMPHASIS ON UNIVERSITY BASIC RESEARCH SHRANK WHILE NEARER-TERM STIMULI FOR TECHNOLOGY THROUGH APPLIED RESEARCH WAS FAVORED. WITH THE EXCEPTION OF THE NATIONAL SCIENCE FOUNDATION AND THE NATIONAL INSTITUTES OF HEALTH, DURING THE 1970S THE MAJOR FEDERAL R&D AGENCIES--DOD, DOE, NASA--DIVERTED RESEARCH FUNDING AWAY FROM UNIVERSITIES TO THEIR OWN LABORATORIES OR TO INDUSTRY.

THE UNIVERSITIES, IN A FINANCIAL BIND, DID WHAT YOU OR I WOULD PROBABLY CHOOSE TO DO. IN ORDER TO SUPPORT RESEARCHERS AND STUDENTS, THEY CUT OTHER EXPENDITURES. THAT MEANT DEFERRING IMPROVEMENTS TO FACILITIES, DEFERRING PURCHASE AND EVEN MAINTENANCE OF INSTRUMENTATION, AND, IN GENERAL, CONSERVING PROGRAMS THEY HAD, RATHER THAN UNDERTAKING NEW ONES. SO IN A VERY REAL SENSE THE ECONOMIZING ACTIONS THEY HAD TO TAKE IN THE 1970S WHEN BASIC RESEARCH SUPPORT FELL OFF LED TO SOME OF THE PROBLEMS WE SEE TODAY.

THE RESULTING DETERIORATION OF RESEARCH INSTRUMENTATION AT U.S. UNIVERSITIES AND COLLEGES HAS BEEN THE SUBJECT OF A NUMBER OF STUDIES. IN A RECENT NSF SURVEY, OFFICIALS OF 43 UNIVERSITIES AND COLLEGES CLASSIFIED 25 PERCENT OF THEIR RESEARCH EQUIPMENT AS OBSOLETE. IN FACT, OF ALL ACADEMIC RESEARCH EQUIPMENT IN USE IN 1982, ONLY 16 PERCENT WAS CHARACTERIZED AS BEING "STATE OF THE ART." THESE DEFICIENCIES DIRECTLY AFFECT THE ABILITY OF THE UNIVERSITY SCIENTISTS TO CONDUCT FRONT-LINE RESEARCH, THEY HAMPER THE ABILITY OF STUDENTS TO LEARN THE NEWEST TECHNOLOGIES, AND THEY MAKE IT MORE DIFFICULT FOR UNIVERSITIES TO COMPETE WITH INDUSTRY FOR FACULTY IN AREAS THAT ARE STRONGLY DEPENDENT ON THE USE OF MODERN RESEARCH EQUIPMENT.

THIS INSTRUMENTATION PROBLEM HAS MANY CAUSES, NOT THE LEAST OF WHICH IS THE PACE OF TODAY'S TECHNOLOGICAL PROGRESS, WHICH QUICKLY RENDERS SCIENTIFIC INSTRUMENTATION OBSOLETE. FOR THAT REASON WE HAVE TO RECOGNIZE IT NOT ONLY AS AN ACUTE PROBLEM TODAY, BUT AS A CONTINUING PROBLEM FROM NOW ON. WE'LL ALWAYS BE FACED WITH PRESSURES TO IMPROVE UNIVERSITY INSTRUMENTATION. FOR THAT REASON, THERE CAN BE NO SUCH THING AS A ONE-SHOT SOLUTION. THE FEDERAL GOVERNMENT, WHICH HAS BEEN THE PRIMARY SOURCE OF UNIVERSITY INSTRUMENTATION FOR THE PAST FORTY YEARS, CLEARLY HAS A RESPONSIBILITY. BUT WE SHOULD ALSO BE AWARE THAT THIS IS A SITUATION IN WHICH INDUSTRY CAN PROVIDE SIGNIFICANT ASSISTANCE, PARTICULARLY IF UNIVERSITIES ARE ENCOURAGED AND PERMITTED TO EXPLORE NEW METHODS FOR FINANCING THE PURCHASE AND LEASE OF INSTRUMENTS. WE SHOULD CERTAINLY TRY TO CONTINUE TO SEARCH FOR WAYS TO STIMULATE UNIVERSITY-INDUSTRY COOPERATION TO ADDRESS THESE NEEDS.

AT THE SAME TIME THE ADMINISTRATION HAS ALREADY PROPOSED SUBSTANTIAL INCREASES IN FUNDING FOR INSTRUMENTATION OVER THE PAST FEW YEARS. IN FISCAL YEARS 1984 AND '85 WE EXPECT A TOTAL OF MORE THAN $800 MILLION IN FEDERAL FUNDS TO BE APPLIED TO HIGH-PRIORITY INSTRUMENTATION NEEDS IN UNIVERSITIES. THERE HAVE BEEN SOME SPECIFIC INSTRUMENTATION PROGRAMS ESTABLISHED IN FEDERAL AGENCIES, AND THOSE ARE PARTICULARLY USEFUL IN PROVIDING MAJOR INSTRUMENTATION THAT WILL BE AVAILABLE TO A LARGE NUMBER OF USERS. AT THE SAME TIME, THE BULK OF THE FEDERAL FUNDING WILL BE MADE IN CONJUNCTION WITH RESEARCH GRANTS. THIS MECHANISM, WHICH TIES THE INSTRUMENTATION DIRECTLY TO THE HIGHEST PRIORITY RESEARCH BEING FUNDED BY AN AGENCY, MAKES SURE THE INSTRUMENTATION IS AVAILABLE FOR THOSE RESEARCH PROJECTS THAT CAN MAKE THE BEST USE OF IT. TOGETHER, AND OVER A PERIOD OF YEARS, THESE TWO MECHANISMS SHOULD GREATLY REDUCE THIS PROBLEM OF INADEQUATE INSTRUMENTATION.

AGING RESEARCH FACILITIES--AND BY THAT WE MEAN LABORATORIES AND LARGE RESEARCH TOOLS--CONSTITUTE A DIFFERENT KIND OF PROBLEM, WHICH IS MORE DIFFICULT TO SOLVE. FUNDS FOR NEW LABORATORIES ARE HARD TO FIND, AND UNIVERSITIES ARE PARTICULARLY STRAPPED FOR FUNDS TO MAINTAIN AND NOW RENOVATE AGING FACILITIES. THOSE KINDS OF FUNDS, NOTWITHSTANDING THEIR IMPORTANCE FOR THE RESEARCH ENVIRONMENT, ARE THE SCARCEST OF ALL.

AT THIS POINT IT'S VERY HARD TO GET A GOOD IDEA OF WHAT THE NEEDS ARE. AN _AD HOC_ INTERAGENCY STEERING COMMITTEE WAS FORMED BY NSF IN NOVEMBER OF 1983 TO CONDUCT AN IN-DEPTH STUDY OF THE UNIVERSITY RESEARCH FACILITIES. WE EXPECT SOME RESULTS FROM THIS STUDY BY

FEBRUARY OF 1985.

THE PROBLEMS OF RESEARCH INSTRUMENTATION AND FACILITIES ARE ONLY TWO FACETS OF THE BROADER CONCERN REGARDING THE HEALTH OF U.S. COLLEGES AND UNIVERSITIES. THE REAL QUESTION IS WHETHER THESE INSTITUTIONS WILL BE ABLE TO CONTINUE TO PRODUCE THE LEADING SCIENTISTS AND ENGINEERS THAT THE COUNTRY WILL NEED TO COMPETE. WE HAVE TO ASK OURSELVES IF UNIVERSITIES STILL OFFER THE STRONG SENSE OF STABILITY, EXCITEMENT, AND PERSONAL FREEDOM IN SCIENTIFIC INQUIRY TO ATTRACT FIRST-CLASS FACULTY AND GRADUATE STUDENTS.

THE ANSWER TO THAT QUESTION HAS NOT ALWAYS BEEN ENCOURAGING. CONSIDER THE SHORTAGES OF ENGINEERING FACULTY. THIS SHORTAGE IS PRIMARILY CAUSED BY TWO COUNTERVAILING TRENDS: THE IMPROVING ATTRACTIONS OF PURSUING RESEARCH CAREERS IN INDUSTRY--AND THE DECLINING QUALITY OF LIFE EVEN IN MANY OF OUR LEADING UNIVERSITIES. WE TOOK SOME DIRECT STEPS LAST YEAR TO ADDRESS THIS PROBLEM WITH THE PRESIDENTIAL YOUNG INVESTIGATOR AWARDS PROGRAM. THAT PROGRAM, WHICH WAS STRONGLY ENDORSED BY THIS COMMMITTEE WHEN IT WAS INTRODUCED LAST YEAR, HAS NOW BEEN RECEIVED WITH TREMENDOUS ENTHUSIASM BY BOTH ACADEMIA AND INDUSTRY. AS THE NUMBERS OF YOUNG FACULTY IN THIS PROGRAM GROWS TO ITS TARGET LEVEL OF 1000, WE

EXPECT TO BE ABLE TO CORRECT AND HEAD OFF SOME OF THE MOST SERIOUS FACULTY SHORTAGES IN CRITICAL SCIENTIFIC AND ENGINEERING FIELDS.

COMPLEMENTING THAT FACULTY PROGRAM WILL BE NSF'S NEW PROGRAM TO ESTABLISH UNIVERSITY ENGINEERING RESEARCH CENTERS TO STIMULATE INTERDISCIPLINARY RESEARCH AND TRAINING. THESE CENTERS WILL ALSO PROVIDE A MEANS FOR GREATER INDUSTRIAL PARTICIPATION IN IMPROVING THE UNIVERSITY ENVIRONMENT, BECAUSE THE CENTER PROGRAMS ARE EXPECTED TO HAVE EXTENSIVE COLLABORATION BETWEEN INDUSTRY AND ACADEMIA.

I THINK WE'VE TAKEN SOME MAJOR STEPS TO TURN AROUND THIS PROBLEM OF THE RESEARCH INFRASTRUCTURE IN OUR UNIVERSITIES AND COLLEGES. SPECIFICALLY, THE STRONG GROWTH IN FEDERAL SUPPORT FOR UNIVERSITY RESEARCH, THE EMPHASIS ON INSTRUMENTATION, THE SPECIAL PROGRAMS TO IMPROVE THE LINKAGES BETWEEN INDUSTRY AND ACADEMIA-- ALL CONSTITUTE IMPORTANT CHANGES OVER THE PAST FEW YEARS.

OUR EFFORTS HAVE BEEN GUIDED BY A PRINCIPLE THAT HAPPENS TO BE WELL EXPRESSED IN THAT GUIDE TO KEEPING AMERICA NUMBER ONE, IN SEARCH OF EXCELLENCE. THE PRINCIPLE IS THAT QUALITY MUST COME FIRST; QUANTITY THEN WILL FOLLOW. SO IN WORRYING ABOUT HOW TO TRAIN ENOUGH

TECHNICAL TALENT TO MEET TOMORROW'S NEEDS, OUR FIRST CONCERN HAS TO BE TO FOCUS ON THE QUALITY OF OUR TRAINING-- NOTHING LESS THAN TRAINING THE WORLD'S BEST AND MOST INNOVATIVE SCIENTISTS AND ENGINEERS. EMPHASIS ON QUALITY AND EXCELLENCE IN SCIENCE AND ENGINEERING WILL THEN ATTRACT A SUFFICIENCY OF TALENT.

MR. CHAIRMAN, ALTHOUGH THERE'S BEEN A DE FACTO RELATIONSHIP BETWEEN UNIVERSITIES AND THE FEDERAL GOVERNMENT FOR MORE THAN 40 YEARS, THERE'S BEEN NO EXPLICIT RECOGNITION OF THE NATURE OF THIS RELATIONSHIP NOR OF THE RESPONSIBILITY OF THE FEDERAL GOVERNMENT TOWARD UNIVERSITIES. IN MANY CASES THE UNIVERSITIES, IN SPITE OF THE UNIQUE COMBINATION OF RESEARCH AND TRAINING THAT THEY PROVIDE, HAVE BEEN DEALT WITH BY SOME AGENCIES IN MUCH THE SAME WAY THOSE AGENCIES DEAL WITH CONTRACTORS. MANY UNIVERSITY LEADERS TELL ME THAT, IN THE PAST FEW YEARS, INDUSTRY, WHICH ONE WOULD PRESUME WOULD BE VERY CAREFUL WITH A DOLLAR, HAS PROVIDED LESS CONSTRAINED SUPPORT FOR RESEARCH THAN THE GOVERNMENT. INDUSTRY RECOGNIZES THAT HIGH-QUALITY UNIVERSITY PROGRAMS IN AREAS RELEVANT TO ITS NEEDS WILL, IN THE LONG RUN, STIMULATE THE PRODUCTION OF KNOWLEDGE AND TALENT THAT IT CAN DRAW ON. AND FOR THEM THAT SEEMS TO BE RATIONALE ENOUGH. SO I THINK IT'S TIME FOR GOVERNMENT TO TAKE A FRESH LOOK AT WHETHER THERE COULD BE MORE PRODUCTIVE relationships between mission agencies and universities, relationships that acknowledge the unique role of universities in producing *both* research and *talent*.

For that reason, I have recently asked the White House Science Council to undertake a study of the broad policy questions that affect the current and future health of our colleges and universities. Let me suggest some of the topics that I hope they'll look at.

One would be the issue of the federal government's role in ensuring a productive research environment. This includes the nagging problem of indirect costs, an issue that Secretary Heckler has specifically asked OSTP to address. In response to her request, an OSTP staff working group has been established, and their work will be coordinated with that of the Science Council.

A second area of the study is likely to concern the effects on research productivity of the uncertainties and red tape involved in funding. While we have no intention of even suggesting an entitlement program for research, neither do we see much sense in forcing the most productive researchers and teachers to waste so much of their time playing the grantsmanship games. Some possibilities have been suggested and should be

LOOKED AT. THEY INCLUDE MULTI-YEAR FUNDING CYCLES IN THE CONGRESS; LONGER-TERM PROJECT GRANTS FROM THE AGENCIES; LARGE, FLEXIBLE GRANTS TO INSTITUTIONS INSTEAD OF INDIVIDUAL PROJECT GRANTS; EVEN RESEARCH SUPPORT FOR OUTSTANDING INDIVIDUALS BASED ON A HISTORY OF PERFORMANCE RATHER THAN ON A RESEARCH PROPOSAL.

I WOULD EXPECT THE GROUP ALSO TO LOOK AT THE PROBLEM I DISCUSSED EARLIER--THAT OF THE UNIVERSITY PHYSICAL FACILITIES AND INSTRUMENTATION. ANOTHER QUESTION WORTH A FRESH LOOK IS WHETHER MISSION AGENCIES HAVE SPECIAL RESPONSIBILITIES, OF THE KIND THAT NSF DOES, TO HELP MAINTAIN THE HEALTH OF UNIVERSITIES. AND HOW BROAD ARE THOSE RESPONSIBILITIES?

SINCE I KNOW THE WHITE HOUSE SCIENCE COUNCIL MEMBERS RECOGNIZE THE TREMENDOUS IMPORTANCE TO U.S. UNIVERSITY VITALITY OF FOREIGN STUDENTS AND TEACHERS, I WOULD HOPE THE GROUP WOULD CONSIDER POSITIVE WAYS TO ENCOURAGE AND RETAIN THEM IN THIS COUNTRY--AS OPPOSED TO THAT SENTIMENT THAT WOULD LIMIT THE ACCESS OF THE BEST FOREIGN INTELLECTS TO OUR UNIVERSITIES.

FINALLY, OVER THE PAST FEW YEARS A NEW FACTOR HAS EMERGED IN UNIVERSITIES--THEIR INCREASED INTERACTIONS WITH INDUSTRY. HOW DO WE MAXIMIZE THE BENEFITS TO

UNIVERSITIES OF THIS INTERACTION, AND HOW DO WE MINIMIZE THE RISKS OF COMPROMISING THE RESEARCH ENVIRONMENT WE'RE DETERMINED TO ENHANCE?

I'M ESPECIALLY PLEASED WITH THE PROSPECTS FOR THIS STUDY, AND I WOULD EXPECT THAT ITS OUTCOME WILL PLAY AN IMPORTANT PART IN THE APPROACHES WE PROPOSE TO TAKE IN COMING YEARS.

MR. CHAIRMAN, THAT CONCLUDES MY TESTIMONY. I WOULD BE PLEASED TO RESPOND TO QUESTIONS FROM MEMBERS OF THE COMMITTEE.

Mr. FUQUA. Thank you very much, Dr. Keyworth. We appreciate the very thoughtful statement you have and some of the issues that you touched upon.

I would like to depart just a little bit from the normal procedure of the committee to recognize Dr. Willy Fowler, who is this year's Nobel laureate in physics, who is sitting out in the audience. He has already been up here several months ago, right after we had the reception and hearing from all the Nobel laureates. He has been a great one in research and has benefited research, I think, by the great award that he received this year.

Dr. Fowler, we are very pleased to have you join us today.

Dr. Keyworth, one of the questions I guess we get—and you pointed out in the latter part of your statement about the White House, I guess, Interagency Council that has been doing some long-term work in this, and you outlined a number of things they would be doing—and I am wondering why it seems that the managers of research, both Government and academia, can't do a better job of anticipating some of the long-term needs and requirements [illegible] basic research so that we don't wait until the mule is out of the barn before we cry for help. I'm not being critical. I'm really saying, are we falling down at that point?

Dr. KEYWORTH. Certainly the managers of research must share in our failure to adequately prepare but, Mr. Chairman, I think as a Nation we have recognized just in the last few years that we are in an era that will be characterized by challenges and very intense competition. I think the Nation as a whole failed during what is, in retrospect, the decade of very clear signals, the seventies, as a Nation we failed to prepare, so I think that in that sense the managers of research in the scientific community were in tune, if you wish, with the Nation at that time.

But on top of this we have another trend that I believe we should look at with some humbleness and some willingness to start from first principles, and that is that we have said many a time that technology has moved faster in the last, say, 50 years than at any time in history. But I think that the technological advances of the last 50 years are nothing compared to the technological advances of the next 50 years. We are on a slope that is accelerating in its rate of increase. Who could have imagined just a few years ago that last week IBM would have announced the fabrication of a single semiconductor chip with 1 million bits of memory on it?

We have tough challenges before us and we have enormous changes before us, and we cannot find all the answers. No managers of research can predict them and no scientist can, but we must be flexible and we must, I believe on an annual basis, be asking ourselves here in the executive branch and throughout the scientific community where we are today, what the immediate challenges are, and how prepared we are to meet them.

Mr. **FUQUA**. I would like to correct that. It was the White House Science Council that I was referring to, but I noticed in those recommendations you talk about productive research environment and reducing redtape, and all very good things. I think that helps, but do you see us getting back into programs such as NSF and some of the other agencies that I mentioned in my opening remarks where we have some Federal funding for facilities?

Dr. **KEYWORTH**. I do believe that, as I tried to stress in my testimony, that the universities as a source of talent and fundamental research are so critically important to this Nation's ability to compete, that Government has to enter into a true partnership across the entire board in insuring that the health of those universities is maintained. That does mean looking at the infrastructure, the buildings, the instrumentation, virtually everything.

That does not mean, by any means, that the Government should or is likely to develop a dominant role in the support of buildings, but I think we should approach this issue without biases, without, if you wish, dogmatic guidelines, and we should simply approach the health of universities as I believe you are doing in these hearings, Mr. Chairman, with no presumptions. I do believe that Government will have to be involved in restoring that infrastructure to universities in some way, but the critical thing is this partnership that I keep referring to between academia, industry, and Government.

Mr. **FUQUA**. Well, what role do you see the private sector or industry playing in helping to refurbish the infrastructure of university research?

Dr. **KEYWORTH**. Well, Mr. Chairman, we have seen in the last year introduction of some programs that I think we have all been highly supportive of in a very bipartisan fashion. I will particularly emphasize one, and that is the Presidential Young Investigator Award, to attract and maintain our top young talent into junior faculty positions.

That is a shared Government-industry program, and I think what is so important about that program is not just the sharing of funding but also the fact that industry, the eventual employer of most of that talent, is actively involved in the educational process, is actively involved with telling the academic world what long-term problems they are worrying about and see before them and, if you wish, opening a dialog that has been rather closed due to that adversarial relationship of the past 20 years that I referred to in my testimony.

So I think industry will have a real role. I think they are taking a real role and I think it will be characterized by a long-term partnership to address this era of competitiveness.

Mr. **Fuqua**. Thank you.

Mr. Skeen.

Mr. **Skeen**. Thank you, Mr. Chairman.

Dr. Keyworth, good to see you again this morning.

During the National Science Foundation authorization hearings, we asked a question about the overhead charges that are involved in some of these universities on research funds, and the variation ran from anywhere from 30 up to 80 percent. I am curious: Is the White House Science Council concerned about this, or have you talked about this wide variation? I know the answer that was given us at that time was different methods of accounting in talking about these charges.

Dr. **Keyworth**. Mr. Skeen, first I think I can virtually speak for all the members of the Science Council. They probably would tell you that this is as frustrating an issue as any that has been before them. I have presented the issue of indirect and our concerns about the indirect debate for 2 years to the Council, and we have addressed many, many different avenues of trying to resolve it.

The relative inaction toward removing the debate about indirect has been, I believe, because of the very fundamental nature of the problem and the very difficulty in solving it. Yes, part of the problem is because of accounting techniques, but by no means all of the problem. There are very real differences in the indirect burdens on universities and the fraction, in fact, of the entire university burden that has been carried by the Federal Government.

But, Mr. Skeen, I think at this time what we should do is look forward, not backward; not griping at the universities, not griping at the National Institutes of Health for past action. We should look forward to the means we can take to both restore that university health but to introduce means to provide incentives for universities to control those indirect costs.

So, again—and I will probably use this word "partnership" again—I think we have got to approach this as a clear partnership to address a very real problem. The indirect burden has been growing as a larger and larger fraction of the grants and we must control it, but I think we must approach it in a partnership and not an adversarial way.

Mr. **Skeen**. Dr. Keyworth, I couldn't agree with you more, and I would rather look forward, too. But I think that it's well to tell the people that this, I think characterized in your own terms, this "grantsmanship game" that evidently we have been playing for some time—and universities play it very well, they are probably as good prospective planners as any group I know of, and they are about as good politicans as any group I have ever met—they understand this business as well as anyone. But I think it is important that we at least consider why this wide variation, and any future planning that we do should come to grips with some idea that we either standardize this thing or all go from the same square, about what overhead charges are.

Leaving that, let's look forward. We have had a lot of comment about these peer review groups, a lot of support for the peer review process in the awarding of Federal research funds. I hear a lot about the advantages. Do you see any disadvantages?

Dr. **Keyworth**. Perhaps there is an analogy between the democratic system of government and peer review. Neither is perfect, but no one has found an improvement over either. Of course, there are problems with peer review systems. In fact, I personally believe that if we find ourselves in a position where we are supporting a very, very small fraction of the requested grants, such as 15 percent—which, incidentally, is about half of the fraction that most agencies presently support—I think the peer review system would be confronted with some challenges that it probably is incapable of rationally carrying out.

It works, in other words, in a fairly narrow band, and I don't think the peer review system is directly related to national needs and objectives in other sectors of society. I hope that as this partnership I referred to emerges and becomes a way of life for us, I hope that there will be a closer linkage to the scientific community's perception of needs and the Nation's perception of needs as whole.

Yes, it is fallible, and if I may go back for a moment to your previous question, as I think you know, Mr. Skeen, I approach these issues with skepticism, always skepticism. I think we have to approach both implementation of the peer review system and university arguments about indirect with skepticism but also with open minds.

Mr. **Skeen**. Thank you. I like ending on that good note, doctor. Thank you very much.

Thank you, Mr. Chairman.

Mr. **Fuqua**. Thank you, Mr. Skeen.

Mr. Reid.

Mr. **Reid**. Dr. Keyworth, you have indicated that the Federal Government probably should be involved. How, being more specific, should responsibility for facilities funding be assigned. For example, should the Department of Education have a role?

Dr. **Keyworth**. I think the present arrangement whereby—to be specific about the Department of Education--where the Department of Education has primarily worried about precollege education and the National Science Foundation has primarily worried about research in our university environment, is a healthy balance and a healthy split, but I do feel that all agencies that have any dependence upon science and technology in carrying out their mission, and that includes virtually all agencies, should have the health of universities as part of their concern. Therefore, I would expect the concern and even problem-solving, if you wish, to be part of a much broader spectrum of agencies than we now see.

Mr. **Reid**. Rather than getting into the respective roles of NSF, NIH, NASA, and the other agencies, wouldn't it be better if there were an overall research capital budget?

Dr. **Keyworth**. I think we certainly did our best to review that in the first year of the administration very carefully, to see whether there should be a specific program to restore university instrumentation, and I think there was a very broad consensus—and I have seen it recognized within the scientific community, also—that disconnecting capital equipment from the grant process may be a reasonable short-term fix but in the long term we have got to recognize that allocation for capital equipment has got to be a part of the whole grant process, or we will be right back where we found ourselves a few years ago in 1980. Also, I am afraid that if the allocation of capital equipment funds is given outside of the grant process, it will be distributed evenly but not according to genuine need and potential payoff.

Mr. **Reid**. Many universities have had a policy that they would only accept capital gifts if they covered not only construction but also endowment sufficient to cover future operating and maintenance costs. Would you make a comment on this policy generally?

Dr. **Keyworth**. Mr. Reid, I am delighted that you raised that question because that is a truly fundamental question, I believe, that has to be answered in going from the sixties into the future.

We have failed badly in the past to recognize the commitment required when a large capital commitment is made. In other words, when we build a large facility we have frequently failed to recognize that a realistic assessment of the operating funds is essential to utilizing that facility.

We have, for example, built gigantic accelerators in this country for sums of hundreds of millions of dollars, and then found ourselves using them at 30 percent of the time that is available because of operating constraints. We face now, with our supercomputer thrust, the threat of building major supercomputer centers around the country without the funds to properly utilize them.

The two must be linked, and that is part of the reason why I feel so strongly that capital equipment must be allocated in the same process that allocates operating funds and research grants. You have pointed out a very real need that has very much restricted our ability to optimally use the talent and resources that we have had.

Mr. **Reid**. One last question: States historically have supported, at least partially, university capital development. What is your experience the last several years as to whether or not States have been doing really anything in this regard?

Dr. **Keyworth**. I think States have been doing more and more in the last few years compared to the seventies. I think that is a very positive sign and I think it is consistent with what at least I perceive as the new national emphasis on education in tomorrow's talent.

Interestingly enough, some of the States have been extremely innovative, in fact, I would even go so far as to say somewhat more innovative than we in the Federal Government. I think that there is perhaps an important lesson there but, again, I think the States clearly will be part of the Government-industry-academia partnership, and I think we should look toward this as a means of bringing the individual regions of our country closer to the allocation process.

Mr. **Reid**. Thank you, Mr. Chairman.

Mr. **Fuqua**. Thank you, Mr. Reid.

Mr. Bateman.

Mr. **Bateman**. Thank you, Mr. Chairman.

It is a pleasure to have Dr. Keyworth back before us. I have but one question I would like him to address: Do we have a problem

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with funding duplicating types of facilities—laboratories, instruments—that can be very expensive, as opposed to an approach where colleges and universities are encouraged to share facilities through a consortium or other joint operation of a single facility rather than a proliferation of several of the same type of facilities? Is that any part of the problem?

Dr. KEYWORTH. It certainly is. It really is. We have definitely indulged in some duplication that could have been avoided over the years. I think, Mr. Bateman, if I may broaden this point, I think we are all coming to a conclusion under all these questions, and that is that I think many of us feel that the increases that we have seen in the support of basic research are going to have to be sustained for some period of time, but they must be approached with far more caution than we have done in the past.

We must put even more attention, in fact, I would say more attention than we ever have in the past to making sure that those dollars have sufficient leverage to justify them. We can spend research dollars more effectively than we have in the past. We can use regional centers and national centers, for that matter, more effectively than we have in the past. I believe we can use an involvement of industrial research capability with universities more effectively than we have in the past. Simply put, we can get far more leverage than we have in the past, and I think we have to ask the kind of excellent questions that have been raised so far today.

Mr. BATEMAN. Thank you, Dr. Keyworth.

Thank you, Mr. Chairman.

Mr. FUQUA. Thank you, Mr. Bateman.

Mr. McCandless.

Mr. MCCANDLESS. Thank you, Mr. Chairman.

Most of the areas that I was going to cover have already been covered by other questions, and I will defer my time.

Mr. FUQUA. Thank you, sir.

Mr. Lundine.

Mr. LUNDINE. No questions, Mr. Chairman.

Mr. FUQUA. Mr. MacKay.

Mr. MACKAY. No questions, Mr. Chairman.

Mr. FUQUA. Thank you very much.

Dr. Keyworth, we appreciate very much your being here this morning and contributing to a subject that we are all very much interested in. Thank you very much for joining us.

Dr. KEYWORTH. Thank you, Mr. Chairman.

Mr. FUQUA. Because of the weather, I know some of our witnesses from out of town have had difficulty getting in, and I understand that probably Dr. Rhodes may not be able to get in, but did Dr. Silber make it in yet? I understand Dr. Hess is here, if he will come forward, and also Dr. Young.

Dr. Young, we appreciate your good fortune in being able to be here. We do know that there has been some very inclement weather—more specifically, fog—and that has inhibited or prevented some of our witnesses from being here, but we are very delighted to have you, Dr. Young, as the chancellor of the University of California at Los Angeles. Dr. Young, we are very pleased to have you. I think Dr. Hess is coming in and he may join you at the table.

Dr. Young, we will be pleased to hear from you at this time. If you have a prepared statement and wish to make it part of the record, we will be delighted to do so. If you wish to summarize, that will be fine.

STATEMENT OF DR. CHARLES E. YOUNG, CHANCELLOR, UNIVERSITY OF CALIFORNIA AT LOS ANGELES

Dr. YOUNG. I have submitted a prepared statement, Mr. Chairman, and I would like to summarize that.

Mr. Chairman and members of the committee, I am Charles Young. I am chancellor of UCLA and also serve this year as chairman of the Association of American Universities, and I am testifying on behalf of the University of California and AAU and the National Association of State Universities and Land Grant Colleges. I thank you and the members of the committee for giving me this opportunity to appear before you.

Before I begin my prepared comments, Mr. Chairman, I want to thank you and Mr. Sensenbrenner for the comments you made earlier about the problems that may be associated with using the congressional appropriation process for the funding, to try to solve the problem we have for funding facilities, and your comments about peer review which you know our associations support very strongly.

The Nation's deteriorating public infrastructure has received a good deal of attention in recent months and years. Most of us are now aware that our roads, bridges, ports, and sewer systems are in poor condition. It is perhaps less widely recognized that educational facilities across the Nation are also in disrepair, and for many of the same reasons.

When resources are scarce, renovation of facilities and equipment purchases are often deferred, assuming that 1 year or 2 of delay won't hurt too much, but the delays have gone on for years in the Nation's universities and they have occurred at a time of rapid technological change, the sort of change that demands the use of more sophisticated laboratories and instrumentation. The result is, universities now face a problem of major proportions. Inadequate facilities and outdated equipment are a direct threat across the country to the quality of instructional and research programs.

Describing the situation at the University of California, during the past few years we had come to believe that our physical plant was seriously inadequate to meet our needs but we lacked hard data on that subject, so we undertook a careful and realistic review of our need for facilities over the next decade. What we learned is that we have an enormous problem. The university will need more than $4 billion for facilities renovation and construction in the next decade alone.

Although this is a large sum, it is not difficult to see why the need is so great. Enrollment growth has been the principal driving force behind university facilities development over the past 20 years. The need to accommodate more and more students had to be given top priority, diverting attention from other needs. Now that enrollment is stabilizing, we can no longer ignore those other needs.

There are several kinds of need which have developed. First, obviously, existing buildings deteriorate. Periodically they need paint, light fixtures, floor coverings, roofs, and other replacements, and after a half century or so their systems for heating, ventilation, and power must be replaced.

A second kind of facilities need occurs because the university's academic programs must change over time in order to keep pace with the latest advances in each discipline. This means facilities must change also. For example, modern genetic engineering laboratories must have sophisticated systems for ventilation, waste disposal, and safety. Special air pressure systems are needed for the containment of potentially hazardous materials. Use of electron microscopes requires vibration-free space, a sophisticated electrical system, and special darkroom facilities. Requirements like these make older laboratories obsolete.

Enrollment shifts among disciplines are a third factor in facilities needs. Enrollments in engineering and computer science courses have increased sharply since 1975, for example, while enrollments in the physical sciences have remained fairly stable, and social science and humanities enrollments have declined. Nearly 80 percent of our need—that is, the University of California's need—for instruction and research space is for projects in high technology and science disciplines.

When fewer students enroll in history and more in engineering, simply reassigning space won't work. Classrooms with chalkboards must be turned into scientific laboratories, if that is even possible given the limits of the building's support systems. Because the amount of space needed for laboratory instruction is at least 5 times greater than space for a humanities program, more space and therefore new construction is needed over and above any possible reallocation associated with renovation of existing space.

At the University of California, historical shortages of space generate a fourth kind of need. Finally, there is a fifth need, and that is to update facilities continually in order to meet changing code requirements and standards for health and safety, including—especially in California—seismic safety.

I have cited a variety of reasons why the University of California's facilities need extensive renewal. Many of these same reasons also apply to the need to renew instrumentation used in instruction and research. We estimate the University of California's inventory of fully depreciated, obsolete instructional equipment at about $230 million.

The problem is especially critical in engineering and the sciences. In fields such as biochemistry and electrical engineering, many students have to watch demonstrations instead of getting hands-on experience with modern instrumentation. Increasingly, students and faculty in genetic engineering, biotechnology, and other sciences are confronted with research programs that are not solvable using the instrumentation available to them.

The economy of the United States is increasingly dependent on high technology industry, and universities play an important role in maintaining the health of this sector. We provide the research which leads to technological advances and we train the work force of engineers, computer scientists, and biologists. Improved funding for facilities and instrumentation is needed to strengthen the capability of universities to contribute to the Nation's long-term economic viability.

The sums needed, as I have indicated, are enormous. For facilities alone, as I indicated earlier, the University of California needs $4 billion over the next decade. California has about 10 percent of the country's population and receives about 10 percent of Federal research grants. If we expand the University of California's needs to take account of the private research universities in our State, we could conservatively estimate the national need to be 10 times $5 to $6 billion, or $50 to $60 billion. The obvious question is, Where will that much money come from?

At the University of California and, I believe, across the country at other universities, we have come to some important conclusions on this point. We believe that the Nation's universities must do three things: (1) use existing resources as effectively as possible; (2) develop new sources of funds; and, (3) reconsider traditional assumptions about responsibilities for capital development.

The era we are about to enter will have to be one of nontraditional approaches and mixed fund sources if, at the end of the decade, the universities are to emerge with the facilities and instrumentation they need. What we seek is not immediate relief but, rather, renewed long-term commitments from all those who have a stake in the future of higher education in this country: from State government; from business, industry, and private donors; from universities and their students themselves; and, last, from the Federal Government. It will take all of us working together to solve the problem.

Historically, the Federal Government has assumed a major role in funding educational facilities. This has been accomplished in several ways, including grants, loan subsidies, and overhead payments. Prior to 1964, Federal funds were directed almost entirely to research needs.

Between 1964 and 1980, Federal funds were directed toward accommodating the rapidly expanding enrollments in higher education and providing increased numbers, especially of health care professionals. Federal funds received by the University of California during that 20-year period were often matched by State funds, an approach that remains valid today. Since 1977, however, the university has received very few Federal grants for capital projects. State funds for capital projects around the country also declined dramatically at the same time that they were declining at the Federal level.

Although it may be surprising for a State-supported university, our capital development in recent years has been funded not primarily by the State but by the university itself, through user charges, fundraising, hospital revenues and reserves, and student fees. Between 1978 and 1981, nongovernmental funds provided an average of 77 percent of the university's capital expenditures; State funds, 22 percent; and Federal contributions, 1 percent. If funding continues at the levels of the past 5 years, less than 20 percent of the necessary funding will be forthcoming. The university's facilities will deteriorate further, needs for new facilities will not be met, and our academic programs will have suffered significantly.

The Federal Government has a history of responding to the needs of the Nation's universities, and of investing in them in ways that address national priorities. There is an urgent need now for a renewed Federal investment in facilities and instrumentation for higher education. I would like to offer several approaches that I think could be considered.

Facilities grants could be tied to research funding. The Federal Government has made a major financial commitment to the research effort in this country, but university research efforts in fields such as biogenetics, solid-state electronics, and robotics are handicapped by inadequate facilities. To address this problem, funds for facilities could be granted in connection with the funding of research programs, perhaps tied to specific kinds of research projects in science and technology. It might also be possible to create a special facilities program through NSF that would make funds available to research universities based on the proportion of Federal research dollars they receive.

As another approach, universities could be included in programs to renew the Nation's infrastructure generally. Universities are surely as critical a resource as bridges and roads. Funds could also be made available through a federally run program or through block grants to the States. A federally run program might base priorities on criteria that consider past performance and future promise in meeting the country's needs.

Other possibilities include various forms of partnership with the States in ways that leverage State funds, perhaps through matching grants. Tax incentives which further encourage business and industry contributions in an appropriation fashion would be another useful approach. It will be important, also, to continue Federal programs which assist in financing student housing and other self-supporting enterprises in higher education.

These are suggestions only, meant as a help in starting discussion on a national problem that requires a joint effort for solution. Higher education and the Federal Government have worked together before and must now again to address problems which could affect the future health of this country.

In closing, let me briefly summarize the situation: If the University of California's experience is typical, and we believe it is, major funding is needed by universities around the country for facilities renewal and construction and for instrumentation upgrading. Traditional funding approaches will not come close to meeting the need which currently exists. Renewed commitments are required from all funding sources, including the Federal Government. No one agency or group is able to take on the burden alone. The Nation cannot put off a solution any longer. Together, we must begin finding solutions now.

Mr. Chairman, members of the committee, this concludes my presentation. I will, of course, be happy to respond to questions following the rest of the program.

[The biographical sketch and prepared statement of Dr. Young follow:]

UCLA
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BIOGRAPHICAL PROFILE
UCLA CHANCELLOR CHARLES E. YOUNG

Dr. Charles E. Young's leadership as the Chancellor of UCLA is in its 16th year, having begun with his appointment as Chancellor on September 1, 1968. Combined with his previous (1960-1968) administrative positions at UCLA, Chancellor Young's influence has guided the Los Angeles campus of the nine-campus University of California system for approximately a quarter of a century.

Considered one of higher education's senior administrators even though only 52 years old, Dr. Young has continued to direct the rapid growth of UCLA as one of the nation's most comprehensive and dynamic university campuses. Today UCLA is considered by most standards to be one of the half dozen academic institutions commonly identified as the top-ranked major research universities in the U.S. as well as a leader in programs of higher education at the international level.

UCLA's three-fold mission for excellence in education, research, and community service is reflected in the work of its world-recognized 13 professional schools and colleges, 69 departments, 23 organized research units, a library collection of over 5,000,000 volumes, and the renowned UCLA Center for the Health Sciences. Located on 411 acres in West Los Angeles, UCLA has approximately 4,000 academic employees and nearly 13,000 staff members.

Student enrollment at UCLA is approaching an annual average of 32,000, the largest of any of the University of California campuses. Nearly 100,000 adults also attend the University each year on a part-time basis through the popular Extension Program.

With responsibility for an annual expenditure exceeding $750 million, Chancellor Young is chief executive officer of a complex operation which economically corresponds to one of the 50 largest corporations in California.

During his tenure, support for the University has grown extensively from all areas, but especially from the private sector. In recent years, UCLA has become one of the top recipients of private funds among all universities-public or independent.

Charles Young was born in San Bernardino, California, December 30, 1931, where he attended high school. He and his wife, the former Sue Daugherty, have two children, Charles Jr., 28, and Elizabeth Susan, 23, and four grandchildren.

After military service in the Korean War, he enrolled at the newly established campus of the University of California, Riverside, graduating with honors in 1955. While there, he was elected the campus' first student body president.

He then enrolled at UCLA where he studied for his master of arts degree (1957) and doctor of philosophy degree (1960) in political science. In 1958, he went to Washington, D.C., on a Congressional Fellowship and worked with Congressman Lee Metcalf and Senator James Murray, both of Montana.

In 1959, UC President Clark Kerr lured Dr. Young back to California with an offer to join his staff. For about a year he served as staff assistant to the academic team drawing up the Master Plan for Higher Education in California, worked on the University Growth Plan, and studied University decentralization. He also taught political science at UC Davis.

Dr. Young was named Assistant to the Chancellor and Assistant Professor of political science at UCLA in the fall of 1960 by Dr. Franklin D. Murphy who had just assumed the UCLA Chancellorship. In 1962, he became Assistant Chancellor and in 1963, was named Vice Chancellor for Administration. Following Chancellor Murphy's resignation in 1968, Dr. Young was named by the UC Regents as Chancellor at the age of 36, the youngest Chancellor ever appointed by The Regents. Dr. Young continues to hold an academic appointment as professor of political science at UCLA with his writing and teaching in the area of American political theory and politics.

Throughout his tenure at UCLA, Chancellor Young has been active in academic, business and civic organizations. In October, 1983, he was named by his peers to be chairman of the Association of American Universities, an organization comprised of 52 of the most prestigious research universities in North America.

He is a member of the Administrative Board, International Association of Universities; the Board of Governors, Foundation for the International Exchange of Scientific and Cultural Information by Telecommunications; the Los Angeles World Affairs Council; the Southern California Theatre Association; the National Committee on United States-China Relations, Inc.; the Mansfield

Center for Pacific Affairs; the Los Angeles Olympic Organizing Committee; The Los Angeles International Visitors Council; the Greater Los Angeles Energy Coalition; and Board of Trustees, UCLA Foundation.

He also serves on the board of directors of UMF Systems, Inc., Intel Corp., Carlsberg Corporation, Financial Corporation of America, Micro-Z Corp., and American Savings and Loan Association.

February, 1984

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE & TECHNOLOGY
MAY 8, 1984; 9:30 A.M.

CHANCELLOR CHARLES E. YOUNG
UNIVERSITY OF CALIFORNIA
AT LOS ANGELES

FACILITIES AND INSTRUMENTATION NEEDS OF UNIVERSITIES

MR. CHAIRMAN AND MEMBERS OF THE COMMITTEE, MY NAME IS CHARLES YOUNG; I AM CHANCELLOR OF THE LOS ANGELES CAMPUS OF THE UNIVERSITY OF CALIFORNIA. THANK YOU FOR GIVING ME THIS OPPORTUNITY TO MEET WITH YOU.

THE NATION'S DETERIORATING PUBLIC INFRASTRUCTURE HAS RECEIVED A GOOD DEAL OF ATTENTION. MOST OF US ARE NOW AWARE THAT OUR ROADS, BRIDGES, PORTS, AND SEWER SYSTEMS ARE IN POOR CONDITION. IT IS PERHAPS LESS WIDELY RECOGNIZED THAT EDUCATIONAL FACILITIES ACROSS THE NATION ARE ALSO IN DISREPAIR--AND FOR MANY OF THE SAME REASONS. WHEN RESOURCES ARE SCARCE, RENOVATION OF FACILITIES AND EQUIPMENT PURCHASE ARE OFTEN DEFERRED--ASSUMING THAT A YEAR OR TWO OF DELAY WON'T HURT. BUT, THE DELAYS HAVE GONE ON FOR YEARS IN THE NATION'S UNIVERSITIES. AND THEY HAVE OCCURRED AT A TIME OF RAPID TECHNOLOGICAL CHANGE--THE SORT OF CHANGE THAT DEMANDS THE USE OF MORE SOPHISTICATED LABORATORIES AND INSTRUMENTATION. THE RESULT IS, UNIVERSITIES NOW FACE A PROBLEM OF MAJOR PROPORTIONS. INADEQUATE FACILITIES AND OUTDATED EQUIPMENT ARE A DIRECT THREAT, ACROSS THE COUNTRY, TO THE QUALITY OF INSTRUCTIONAL AND RESEARCH PROGRAMS.

I CAN GIVE YOU SOME IDEA OF THE MAGNITUDE OF THE PROBLEM BY DESCRIBING THE SITUATION AT THE UNIVERSITY OF CALIFORNIA. DURING THE PAST FEW YEARS, WE HAD COME TO BELIEVE THAT OUR PHYSICAL PLANT WAS SERIOUSLY INADEQUATE TO OUR NEEDS, BUT WE LACKED HARD DATA ON THE SUBJECT. SO WE UNDERTOOK A CAREFUL AND REALISTIC REVIEW OF OUR NEED FOR FACILITIES FUNDING OVER THE NEXT DECADE. WHAT WE LEARNED IS THAT WE HAVE AN ENORMOUS PROBLEM: THE UNIVERSITY WILL NEED MORE THAN $4 BILLION FOR FACILITIES RENOVATION AND CONSTRUCTION IN THE NEXT DECADE.

THIS BREAKS DOWN INTO SEVERAL MAJOR COMPONENTS:

-- $1.6 BILLION WILL BE NEEDED FOR CONSTRUCTION OR MAJOR RENOVATION OF BASIC ACADEMIC FACILITIES HOUSING INSTRUCTIONAL AND RESEARCH PROGRAMS, LIBRARIES, PUBLIC SERVICE PROGRAMS, HOSPITALS AND CLINICS, AND ADMINISTRATION.

-- $900 MILLION WILL BE NEEDED TO KEEP EXISTING FACILITIES FUNCTIONING SAFELY AND EFFICIENTLY, INCLUDING CORRECTIONS FOR SEISMIC SAFETY.

-- ABOUT $500 MILLION WILL BE NEEDED FOR SELF-SUPPORTING ENTERPRISES SUCH AS STUDENT AND FACULTY HOUSING AND STUDENT ACTIVITIES.

-- AND, IN ADDITION, WE NEED NEARLY $1 BILLION OF ADDITIONAL OPERATING BUDGET FUNDS TO BRING THE LEVEL OF ROUTINE BUILDING MAINTENANCE UP TO STANDARD AND TO ELIMINATE A LARGE BACKLOG OF DEFERRED MAINTENANCE PROJECTS.

ALTHOUGH THESE ARE LARGE SUMS, IT IS NOT DIFFICULT TO SEE WHY THE NEED IS SO GREAT. ENROLLMENT GROWTH HAS BEEN THE PRINCIPAL DRIVING FORCE BEHIND UNIVERSITY FACILITIES DEVELOPMENT OVER THE PAST TWENTY YEARS. THE NEED TO ACCOMMODATE MORE AND MORE STUDENTS HAD TO BE GIVEN TOP PRIORITY, DIVERTING ATTENTION FROM OTHER NEEDS. NOW THAT ENROLLMENT IS STABILIZING, WE CAN NO LONGER IGNORE THOSE OTHER NEEDS.

THERE ARE SEVERAL KINDS OF NEED WHICH HAVE DEVELOPED. FIRST, OBVIOUSLY, EXISTING BUILDINGS DETERIORATE. PERIODICALLY, THEY NEED PAINT, LIGHT FIXTURES, FLOOR COVERINGS, ROOFS, AND OTHER REPLACEMENTS. AND AFTER A HALF CENTURY OR SO, THEIR SYSTEMS FOR HEATING, VENTILATION, AND POWER MUST BE REPLACED. SPACE IN UNIVERSITY OF CALIFORNIA FACILITIES MORE THAN DOUBLED IN THE 15 YEARS PRIOR TO 1971. NOW, SOME 15-20 YEARS LATER, THE BUILDINGS BUILT BACK THEN ARE AGING. THEY ARE COMING INTO A PERIOD WHEN THEY NEED MAJOR MAINTENANCE.

A SECOND KIND OF FACILITIES NEED OCCURS BECAUSE THE UNIVERSITY'S ACADEMIC PROGRAMS MUST CHANGE OVER TIME IN ORDER TO KEEP PACE WITH THE LATEST ADVANCES IN EACH DISCIPLINE. OFTEN THIS MEANS FACILITIES MUST CHANGE ALSO. FOR EXAMPLE, RAPID TECHNOLOGICAL DEVELOPMENT IN THE BIOLOGICAL SCIENCES HAS REQUIRED NOT ONLY NEW KINDS OF EQUIPMENT BUT ALSO NEW KINDS OF BUILDING SYSTEMS. MODERN GENETIC-ENGINEERING LABORATORIES MUST HAVE SOPHISTICATED SYSTEMS FOR VENTILATION, WASTE DISPOSAL, AND SAFETY. SPECIAL AIR PRESSURE SYSTEMS ARE NEEDED FOR THE CONTAINMENT OF POTENTIALLY HAZARDOUS MATERIALS. USE OF ELECTRON MICROSCOPES REQUIRES VIBRATION-FREE SPACE, A SOPHISTICATED ELECTRICAL SYSTEM, AND SPECIAL DARK ROOM FACILITIES. REQUIREMENTS LIKE THESE MAKE OLDER LABORATORIES OBSOLETE. AND OBSOLETE LABORATORIES COMPROMISE THE TEACHING PROGRAM, DEPRIVING OUR STUDENTS OF STATE-OF-THE-ART INSTRUCTION.

ENROLLMENT SHIFTS AMONG DISCIPLINES ARE A THIRD FACTOR IN FACILITIES NEEDS. ENROLLMENTS IN ENGINEERING AND COMPUTER SCIENCE COURSES HAVE INCREASED SHARPLY SINCE 1975, FOR EXAMPLE, WHILE ENROLLMENTS IN THE PHYSICAL SCIENCES HAVE REMAINED RELATIVELY STABLE, AND SOCIAL SCIENCE AND HUMANITIES ENROLLMENTS HAVE DECLINED. NEARLY 80 PERCENT OF OUR NEED FOR INSTRUCTION AND RESEARCH SPACE IS FOR PROJECTS IN HIGH TECHNOLOGY AND SCIENCE DISCIPLINES. WHEN FEWER STUDENTS ENROLL IN HISTORY, AND MORE IN ENGINEERING, SIMPLY REASSIGNING SPACE WON'T WORK. CLASSROOMS WITH CHALKBOARDS

MUST BE TURNED INTO SCIENTIFIC LABORATORIES--IF THAT IS EVEN POSSIBLE GIVEN THE LIMITS OF THE BUILDING'S SUPPORT SYSTEMS. BECAUSE THE AMOUNT OF SPACE NEEDED FOR LABORATORY INSTRUCTION IS AT LEAST FIVE TIMES GREATER THAN SPACE FOR A HUMANITIES PROGRAM, NEW CONSTRUCTION IS NEEDED.

AT THE UNIVERSITY OF CALIFORNIA, HISTORICAL SHORTAGES OF SPACE GENERATE A FOURTH KIND OF NEED. AND FINALLY, THERE IS A FIFTH NEED, AND THAT IS TO UPDATE FACILITIES CONTINUALLY IN ORDER TO MEET CHANGING CODE REQUIREMENTS AND STANDARDS FOR HEALTH AND SAFETY, INCLUDING SEISMIC SAFETY.

I HAVE CITED A VARIETY OF REASONS WHY THE UNIVERSITY OF CALIFORNIA'S FACILITIES NEED EXTENSIVE RENEWAL. MANY OF THESE SAME REASONS ALSO APPLY TO THE NEED TO RENEW INSTRUMENTATION USED IN INSTRUCTION AND RESEARCH. WE ESTIMATE THE UNIVERSITY OF CALIFORNIA'S INVENTORY OF FULLY DEPRECIATED, OBSOLETE INSTRUCTIONAL EQUIPMENT AT NEARLY $230 MILLION. THE PROBLEM IS ESPECIALLY CRITICAL IN ENGINEERING AND THE SCIENCES WHERE ENROLLMENTS HAVE INCREASED SO RAPIDLY IN RECENT YEARS. THE SHORTAGE OF MODERN EQUIPMENT HAS CAUSED ACADEMIC DEPARTMENTS TO REDESIGN COURSES AROUND LESS EFFECTIVE AND OUTDATED EQUIPMENT, TO ELIMINATE EXPERIMENTS AND EXERCISES FROM LABORATORY SESSIONS, OR TO REDUCE THE LENGTH OF LABORATORY SESSIONS IN ORDER TO MEET STUDENT DEMAND. IN FIELDS SUCH AS BIOCHEMISTRY AND ELECTRICAL ENGINEERING, MANY STUDENTS HAVE TO WATCH DEMONSTRATIONS

INSTEAD OF GETTING HANDS-ON EXPERIENCE WITH THE EQUIPMENT. INCREASINGLY, STUDENTS AND FACULTY IN GENETIC ENGINEERING, BIOTECHNOLOGY, AND OTHER SCIENCES ARE CONFRONTED WITH RESEARCH PROBLEMS THAT ARE NOT SOLVABLE USING THE INSTRUMENTATION AVAILABLE TO THEM. IN SHORT, IN FIELDS WHICH ARE MOST IMPORTANT TO THE NATION'S FUTURE ECONOMIC WELL BEING, STUDENTS ARE BEING DENIED THE OPPORTUNITY TO UNDERSTAND THE MOST RECENT DEVELOPMENTS IN THEIR FIELD AND THE QUALITY OF ACADEMIC PROGRAMS IS BEING UNDERMINED.

FUNDS ARE NEEDED, ALSO, TO SUPPORT THE GROWING USE OF COMPUTERS IN ALL DISCIPLINES, NOT JUST IN THE HARD SCIENCES. WHILE ADVANCES IN COMPUTER TECHNOLOGY HAVE LOWERED EQUIPMENT AND OPERATING COSTS, THESE SAVINGS ARE OUTSTRIPPED BY INCREASED STUDENT DEMAND FOR COMPUTER INSTRUCTION. LET ME GIVE YOU JUST ONE EXAMPLE OF THE DEMAND. ONE OF THE UNIVERSITY'S CAMPUSES HAS A RULE FOR SECURITY OF THE COMPUTER ROOM: "LAST ONE OUT LOCKS THE DOOR." THAT MAY NOT SEEM LIKE A GREAT SECURITY SYSTEM TO YOU, BUT IT WORKS FINE. HOW? BECAUSE THE COMPUTER ROOM IS IN USE AROUND THE CLOCK, 24 HOURS A DAY. STUDENTS ARE WAITING IN LINE AT 3 AND 4 IN THE MORNING TO USE A COMPUTER. THERE IS NEVER A "LAST ONE OUT" AND NEVER AN OCCASION TO LOCK THE DOOR.

THE ECONOMY OF THE UNITED STATES IS INCREASINGLY DEPENDENT ON HIGH TECHNOLOGY INDUSTRY, AND UNIVERSITIES PLAY AN IMPORTANT ROLE IN MAINTAINING THE HEALTH OF THIS SECTOR. WE PROVIDE THE RESEARCH WHICH LEADS TO TECHNOLOGICAL ADVANCES, AND WE TRAIN THE WORKFORCE OF ENGINEERS, COMPUTER SCIENTISTS, AND BIOLOGISTS. IMPROVED FUNDING FOR FACILITIES AND INSTRUMENTATION IS NEEDED TO STRENGTHEN THE CAPABILITY OF UNIVERSITIES TO CONTRIBUTE TO THE NATION'S LONG-TERM ECONOMIC VITALITY.

THE SUMS NEEDED ARE ENORMOUS. FOR FACILITIES ALONE, AS I INDICATED EARLIER, THE UNIVERSITY OF CALIFORNIA NEEDS $4 BILLION OVER THE NEXT DECADE. BECAUSE CALIFORNIA HAS ABOUT 10% OF THE COUNTRY'S POPULATION AND RECEIVES ABOUT 10% OF FEDERAL RESEARCH GRANTS, WE COULD CONSERVATIVELY ESTIMATE THE NATIONAL NEED AT 10 TIMES $4 BILLION--OR $40 BILLION. THE OBVIOUS QUESTION IS, WHERE WILL THAT MUCH MONEY COME FROM.

AT THE UNIVERSITY OF CALIFORNIA, WE HAVE COME TO SOME IMPORTANT CONCLUSIONS ON THIS POINT. WE BELIEVE THAT THE NATION'S UNIVERSITIES MUST DO THREE THINGS: ONE, USE EXISTING RESOURCES AS EFFECTIVELY AS POSSIBLE; TWO, DEVELOP NEW SOURCES OF FUNDS; AND THREE, RECONSIDER TRADITIONAL ASSUMPTIONS ABOUT RESPONSIBILITIES FOR CAPITAL DEVELOPMENT. THE ERA WE ARE ABOUT TO ENTER WILL HAVE TO BE ONE OF NONTRADITIONAL APPROACHES AND MIXED FUND SOURCES IF, AT THE

END OF THE DECADE, THE UNIVERSITIES ARE TO EMERGE WITH THE FACILITIES AND INSTRUMENTATION THEY NEED. WHAT WE SEEK IS NOT IMMEDIATE RELIEF, BUT RATHER RENEWED LONG-TERM COMMITMENTS FROM ALL WHO HAVE A STAKE IN THE FUTURE OF HIGHER EDUCATION IN THIS COUNTRY:

-- FROM CALIFORNIA AND THE OTHER STATES
-- FROM BUSINESS, INDUSTRY, AND PRIVATE DONORS
-- FROM UNIVERSITIES AND THEIR STUDENTS
-- AND, FROM THE FEDERAL GOVERNMENT.

IT WILL TAKE ALL OF US WORKING TOGETHER TO SOLVE THE PROBLEM. FORTUNATELY, WE ARE ALREADY SEEING SOME PROGRESS. THE STATE OF CALIFORNIA HAS BEGUN MOVING TOWARD SIGNIFICANT BUDGET INCREASES FOR THE UNIVERSITY'S CAPITAL DEVELOPMENT AND EQUIPMENT REPLACEMENT PROGRAMS. BUSINESS AND INDUSTRY ARE TAKING A MORE ACTIVE ROLE; FOR EXAMPLE, IBM HAS AGREED TO PROVIDE SUBSTANTIAL FINANCIAL SUPPORT FOR DEVELOPMENT OF NEW ACADEMIC COMPUTING TECHNOLOGIES. UNIVERSITY CAMPUSES INCREASINGLY HAVE DIRECTED THEIR LIMITED NON-STATE RESOURCES TOWARD MEETING THE NEEDS. NOW, WE NEED YOUR HELP.

HISTORICALLY, THE FEDERAL GOVERNMENT HAS ASSUMED A MAJOR ROLE IN FUNDING EDUCATIONAL FACILITIES. THIS HAS BEEN ACCOMPLISHED IN SEVERAL WAYS, INCLUDING GRANTS, LOAN SUBSIDIES, AND OVERHEAD PAYMENTS. PRIOR TO 1964, FEDERAL FUNDS WERE DIRECTED ALMOST ENTIRELY TO RESEARCH NEEDS.

BETWEEN 1960 AND 1980, FEDERAL FUNDS WERE DIRECTED TOWARD ACCOMMODATING THE RAPIDLY EXPANDING ENROLLMENTS IN HIGHER EDUCATION AND PROVIDING INCREASED NUMBERS OF HEALTH CARE PROFESSIONALS. FEDERAL FUNDS RECEIVED BY THE UNIVERSITY OF CALIFORNIA DURING THAT 20-YEAR PERIOD WERE OFTEN MATCHED BY STATE FUNDS--AN APPROCH THAT REMAINS VALID TODAY. SINCE 1977, HOWEVER, THE UNIVERSITY HAS RECEIVED VERY FEW FEDERAL GRANTS FOR CAPITAL PROJECTS. STATE FUNDS FOR CAPITAL PROJECTS ALSO DECLINED DRAMATICALLY AT THE SAME TIME. ALTHOUGH IT MAY BE SURPRISING FOR A STATE-SUPORTED UNIVERSITY, OUR CAPITAL DEVELOPMENT IN RECENT YEARS HAS BEEN FUNDED NOT PRIMARILY BY THE STATE BUT BY THE UNIVERSITY ITSELF THROUGH USER CHARGES, FUND RAISING, HOSPITAL RESERVES, AND STUDENT FEES. BETWEEN 1978 AND 1981, NON-GOVERNMENTAL FUNDS PROVIDED AN AVERAGE OF 77 PERCENT OF THE UNIVERSITY'S CAPITAL EXPENDITURES, STATE FUNDS JUST 22 PERCENT, AND FEDERAL CONTRIBUTIONS 1 PERCENT. IF FUNDING CONTINUES AT THE LEVELS OF THE PAST FIVE YEARS, LESS THAN 20 PERCENT OF THE NECESSARY FUNDING WILL BE FORTHCOMING, THE UNIVERSITY'S FACILITIES WILL DETERIORATE FURTHER, NEEDS FOR NEW FACILITIES WILL NOT BE MET, AND OUR ACADEMIC PROGRAMS WILL SUFFER SIGNIFICANTLY.

The Federal government has a history of responding to the needs of the nation's universities, and of investing in them in ways that address national priorities. There is an urgent need, now, for a renewed Federal investment in facilities and instrumentation for higher education. There are several approaches that could be considered.

For example, facilities grants could be tied to research funding. The Federal government has made a major financial commitment to the research effort in this country. But university research efforts in fields such as bio-genetics, solid-state electronics, and robotics are handicapped by inadequate facilities. To address this problem, funds for facilities could be granted in connection with the funding of research programs--maybe tied to specific kinds of research projects in science and high technology. It might also be possible to create a special facilities program through NSF that would make funds available to universities based on the proportion of Federal research dollars they receive.

As another approach, universities could be included in programs to renew the nation's infrastructure. Universities are surely as critical a resource as bridges and roads, if not more so. Funds could be made available either through a Federally run program or through block grants to the States.

A FEDERALLY RUN PROGRAM MIGHT BASE PRIORITIES ON CRITERIA THAT CONSIDER PAST PERFORMANCE AND FUTURE PROMISE IN MEETING THE COUNTRY'S NEEDS.

OTHER POSSIBILITIES INCLUDE VARIOUS FORMS OF PARTNERSHIP WITH THE STATES IN WAYS THAT LEVERAGE STATE FUNDS--PERHAPS THROUGH MATCHING GRANTS. TAX INCENTIVES WHICH ENCOURAGE BUSINESS AND INDUSTRY CONTRIBUTIONS WOULD BE ANOTHER USEFUL APPROACH. IT WILL BE IMPORTANT, ALSO, TO CONTINUE FEDERAL SUBSIDY PROGRAMS WHICH ASSIST IN FINANCING STUDENT HOUSING AND OTHER SELF-SUPPORTING ENTERPRISES IN HIGHER EDUCATION.

THESE ARE SUGGESTIONS ONLY--MEANT AS A HELP IN STARTING DISCUSSION ON A NATIONAL PROBLEM THAT REQUIRES A JOINT EFFORT FOR SOLUTION. HIGHER EDUCATION AND THE FEDERAL GOVERNMENT HAVE WORKED TOGETHER BEFORE, AND MUST NOW AGAIN, TO ADDRESS PROBLEMS WHICH COULD AFFECT THE FUTURE HEALTH OF THIS COUNTRY.

IN CLOSING, LET ME BRIEFLY SUMMARIZE THE SITUATION:

-- IF THE UNIVERSITY OF CALIFORNIA'S EXPERIENCE IS TYPICAL, AND WE BELIEVE IT IS, MAJOR FUNDING IS NEEDED BY UNIVERSITIES AROUND THE COUNTRY FOR FACILITIES RENEWAL AND CONSTRUCTION AND FOR INSTRUMENTATION UPGRADING.

- -- TRADITIONAL FUNDING APPROACHES WILL NOT COME CLOSE TO MEETING THE NEED.
- -- RENEWED COMMITMENTS ARE REQUIRED FROM ALL FUNDING SOURCES, INCLUDING THE FEDERAL GOVERNMENT. NO ONE AGENCY OR GROUP IS ABLE TO TAKE ON THE BURDEN ALONE.
- -- THE NATION CANNOT PUT OFF A SOLUTION ANY LONGER.

TOGETHER, WE MUST BEGIN FINDING SOLUTIONS NOW.

THAT COMPLETES MY PRESENTATION. I WOULD BE PLEASED TO HAVE YOUR REACTIONS OR QUESTIONS.

Mr. **FUQUA**. Thank you very much, Dr. Young.

At this time we will hear from Dr. Charles Hess, who is just up the road from you somewhat, who is dean of the College of Agriculture and Environmental Sciences at the University of California at Davis.

We are very pleased to have you here, Dr. Hess.

STATEMENT OF DR. CHARLES E. HESS, DEAN, COLLEGE OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES, UNIVERSITY OF CALIFORNIA AT DAVIS

Dr. **HESS**. Thank you, Mr. Chairman.

Also, I am a member of the National Science Board of the National Science Foundation. However, I am presenting the testimony in my role as dean and associate director of the experiment station.

I am very pleased to see the issue of the research infrastructure at U.S. universities is an issue of concern to this committee, to Dr. Keyworth in the Office of Science and Technology Policy, and a number of other groups, including the American Association of Universities, the Interagency Task Force on Academic Research Facilities, the White House Science Council, the National Academy of Sciences Government, Industry, and University Research Roundtable. Also, at the request of Dr. Keyworth the National Science Board will discuss university infrastructure at the June meeting.

From this concerted effort, I think, an accurate picture of the status of the research infrastructure at U.S. universities will emerge, as well as a variety of approaches to addressing the challenges at Federal, State, private, and university levels. I think there is little question that there are challenges. A 1980 AAU report to the National Science Foundation indicated that capital expenditures for instrumentation doubled in the 5-year period from 1975–79 but, even with this increased expenditure, the median age of instrumentation at universities was twice that of industrial laboratories.

My firsthand experience with the equipment problem is in connection with the expansion of a research and teaching program in biotechnology. To recruit and adequately accommodate a scientist in this area of research costs an average of about $125,000 for equipment alone, and this figure does not include the renovation of laboratories, which can range from $30,000 to $60,000. Equipment is critical, not only to attract and retain scientists of the highest caliber, but is equally important in the training of undergraduate and graduate students.

In this area of biotechnology, the differential in the mean age of equipment is undoubtedly even greater than the study reported by AAU. The influx of venture capital into the new biotechnology firms has enabled these firms to set up state-of-the art facilities. It is vital that our students have training and the opportunity to conduct research with equipment of at least equal quality, if they are going to be effective in the private sector.

An index of the need for equipment is found in the Department of Defense initiative on instrumentation. DOD estimated that $1.5 to $2 billion would be required to elevate the academic laboratories to world class status in terms of instrumentation. In response to the first year of a 5-year, $150 million program, DOD received 2,478 proposals totaling $645 million. Two hundred and four awards were made, with each award averaging about $148,000, and that represents an award rate of about 8 percent and a funding level of 4 percent of the amount requested. I think the experience at the Foundation, of course, is that the funding rate may be around 25 percent of the highest quality projects, and I think this indicates that there is a tremendous need in the scientific community.

Space, as Dr. Young has indicated, is also a very crucial limiting factor in the research infrastructure at many universities, both in terms of quality and quantity. An inventory conducted by the U.S. Department of Agriculture in 1978 showed that there was a shortage of 1,110 scientist spaces, equivalent to about 15 percent of the scientific population. Renovation was needed, also, to accommodate about 19 percent of the scientific population or to improve their accommodations.

At UC-Davis, space is now one of the most important limiting factors in recruiting and retaining faculty and graduate students. There has been a great reluctance by Federal and State government, the private sector and foundations, to become involved in the business of bricks and mortar in recent years. State appropriations often have been targeted to alterations or modifications to meet Government regulations for fire, occupational health—as Dr. Young indicated, seismic safety is an issue in California—and for access for the handicapped. State funding for new facilities is driven more by student numbers than research needs and, as we enter a period of declining college-age population, the role of the university in providing basic research needs of the country must not be overlooked.

It is true that in some of the Federal laboratories there is underutilized space. In one case with which I am familiar, the Western Regional Laboratory at Albany, Calif., the U.S. Department of Agriculture is planning a laboratory to do research on gene expression in plants, in collaboration with the University of California at Berkeley and Davis and with private laboratories in the bay area. However, such a facility 65 miles from Davis does not alleviate the space problems on the campus.

A third limiting factor in the university research infrastructure is support personnel. Technicians are an invaluable asset in a faculty member's laboratory for the operation and maintenance of equipment, and to continue experiments for faculty when they must be in class or meeting other university responsibilities. The increased sophistication and cost of today's equipment makes expenditure in support personnel a wise investment.

A fourth factor affecting the university research infrastructure is the ability to attract young people to do graduate work. This is particularly true in engineering but it is also the case in the basic sciences, including plant biology. In the case of engineering, opportunities in industry for B.S. graduates are great enough that many bright young people are choosing to go directly into industry, rather than pursue graduate studies or careers in the university.

The information explosion is placing a strain on a critical component of the research infrastructure of U.S. universities, the library. Space for books and journals is in short supply and, as a partial solution, the University of California has constructed regional facilities to store infrequently used books, much to the concern of the faculty, I must say. The electronic technology for the dissemination and handling of the information may alleviate the problem in the future, but solutions for current needs must be sought.

There is one other constraint in the U.S. research infrastructure that is also related to this information explosion, and that is the transfer of new knowledge generated in the universities to potential users in society. The case is often made that, while the United States is preeminent in basic research, other nations seem better able to translate new ideas into practice. One explanation is that the ties between universities and industries are not close enough.

Some scientists feel that there is value in maintaining some distance between universities in the private sector, so there is complete freedom of inquiry, free exchange of information, and a full opportunity to do basic research without concern for direct application. However, others believe that the scientific community has the responsibility to not only create useful knowledge, but also to evaluate it and present it in a form suitable for application. Later on I will suggest a model which has been successful in agriculture and may be applicable to other industries.

In summary, then, the constraints to the research infrastructure in U.S. universities, as I see them, are equipment, space, support personnel, graduate student support, and the ability to handle the information explosion and translate new information into practice. What, then, are some of the options?

In regard to instrumentation, I encourage enthusiastic support of the DOD program in instrumentation and also the increased funding for instrumentation that has been incorporated into the National Science Foundation grants program. In the Foundation's 1984 budget there was an overall increase of about 60 percent in instrumentation across the directorates, going from approximately

$112 million in 1983 to $180 million in 1984. However, in view of the equipment needs that exist as indicated by the DOD figures, expanded programs would be a wise investment.

A particular challenge at the college or departmental level is equipping laboratories for new faculty. Neither the DOD program nor the NSF programs meet this need. The DOD program is designed to fund large items of equipment used by a number of scientists, and the NSF grants to individual investigators are not really intended to establish laboratories. The President's Young Investigators Awards program conducted by the NSF is a model which could be expanded to meet this need.

Another approach to meet the needs for both equipment and research space is to reinstitute the Graduate Science Facilities program in the National Science Foundation. From 1960-72, the National Science Foundation conducted institutional programs to strengthen research in education in U.S. colleges and universities. In contrast with other NSF programs, which are generally geared toward individual research, there were institutional programs targeted to improve the quality of academic science on a scale at least as broad as a department. The Graduate Science Facilities program required at least 50 percent matching funds by the grantee institution. This matching requirement was intended to stimulate a flow of State and private moneys and to show evidence of local commitment to the program.

The desperate need for facilities has led some universities to make end runs to the Congress, much to the concern and dismay of the scientific community. A program as I have described would give the universities a viable alternative and would provide peer evaluation to help insure the best investment is made with public and private funds. Other agencies, such as the USDA, should be encouraged to develop similar programs. Although authorization for facilities was included in the 1981 agriculture and food bill, funding has not been provided except for the 1890 land grant colleges.

Universities also have a responsibility to insure that equipment is used efficiently. A successful approach at the University of California at Davis has been the establishment of a Center for Advanced Instrumentation. The center serves as a home for major pieces of equipment which can be used not only by faculty at Davis but by scientists from other universities or by the private sector on a recharge basis. The center is staffed with personnel overseeing the operation and maintenance of the equipment. They also help in training individuals to use that equipment, and a portion of the user fees can be used to help replace the obsolete equipment.

The Office of Technology Assessment suggested, in its Report on Commercial Biotechnology: An International Analysis, which I think is a very excellent report, that an option to meet the training needs for biotechnology, as an option Congress might increase the funding for USDA, NIH, and NSF graduate and postdoctoral training grants in plant molecular biology, applied microbiology, and bioprocess engineering. This has been taking place in the Foundation.

The same approach should be considered for all areas of science and engineering in which there is a shortage of trained individuals to meet the needs of the universities and the private sector, and to be sure we continue to attract the finest minds to U.S. research.

Finally, we need to conduct research and develop policy for improved methods of handling and transferring scientific information. The translation should be multidisciplinary and problem-focused. Data availability is not really seen as the problem, as much as the assessment of quality and the packaging of information in a form that is user-friendly. This challenge may be met by professional societies who could provide quality assurance, working with users who in turn could provide an insight as to what is needed and in what ways information could be organized.

Another approach would be to explore a model which has worked for agriculture, to see if it can be applied to other sectors of the economy, and that is the Cooperative Extension Service, the vital link between the researcher and the user of research information, serving not only as an information delivery system but also as a feedback mechanism to bring new problems back to the researcher. The system has dramatically reduced the time from innovation to application in agriculture, and might be applied equally well in engineering. Although the direct transfer of the extension model from one sector to another may not be possible, it is certainly worth exploring to see if we can't match our country's ability to transfer information with our ability to create new knowledge.

Thank you very much.

[The biographical sketch and prepared statement of Dr. Hess follow:]

BIOGRAPHICAL SKETCH

CHARLES E. HESS

Charles E. Hess, Dean of the College of Agricultural and Environmental Sciences at the University of California, Davis, and Associate Director of the California Agricultural Experiment Station.

A native of New Jersey, Hess began his plant science studies at Rutgers University. He graduated in 1953 Phi Beta Kappa with High Honors. He received his M.S. and Ph.D. degrees in 1954 and 1957, respectively, from Cornell University. His major was horticulture with minors in plant physiology and plant pathology.

Hess taught at Purdue University from 1958 until 1966 advancing through the academic ranks to Full Professor. In 1966 he was named Research Professor at Rutgers, where he also served as Chairman of the Department of Horticulture and Forestry from 1966 to 1970.

In 1971 he became Director of the New Jersey Agricultural Experiment Station and Acting Dean of the College of Agricultural and Environmental Sciences. When the latter facility was renamed Cook College in 1972, he was appointed its first Dean. He accepted his UC Davis post in July 1975.

Hess has received numerous awards for his work in the physiology of plant growth regulators, particularly those affecting root formation. He has served on state, national, and international advisory boards and commissions including President and Chairman of the Board of the American Society for Horticultural Science. In October 1982 he received a Presidential appointment to a six-year term on the National Science Board and in May 1983 he received an Honorary Doctor of Agriculture Degree from Purdue University. In February 1984 he was appointed by the Governor to the California State Board of Food and Agriculture for a four-year term.

March 1984

Research Infrastructure at U.S. Universities

Mr. Chairman, my name is Charles E. Hess. I am Dean of the College of Agricultural and Environmental Sciences, University of California, Davis, California and Associate Director of the California Agricultural Experiment Station. Also, I am a member of the National Science Board of the National Science Foundation. I am presenting testimony in my role as Dean and Associate Director.

I am very pleased to see that the issue of research infrastructure at U.S. universities is an issue of concern to this Committee, to Dr. Keyworth and the Office of Science and Technology Policy, and a number of other groups such as the Association of American Universities (AAU), the Interagency Task Force on Academic Research Facilities, the White House Science Council, and the National Academy of Science's Government-University-Industry Research Round Table. Also, the National Science Board (NSB) will discuss university Infrastructure at its June meeting. From this concerted effort an accurate picture of the status of research infrastructure at U.S. universities will emerge as well as a variety of approaches to addressing the challenges at federal, state, private, and university levels.

There is little question that there are challenges. A 1980 AAU report to the National Science Foundation indicated that capital expenditures for instrumentation doubled in the five-year period from 1975 to 1979. Even with the increased expenditure, the median age of instrumentation at universities was twice that of industrial laboratories. My first-hand experience with this equipment problem is in connection with the expansion of our research and teaching programs in biotechnology. To recruit and adequately accommodate one scientist in this area of research costs an average of $125,000 for equipment alone. This figure does not include the cost of renovation of laboratories, which ranges from $30,000 to $60,000. Equipment is critical not only to attract and retain scientists of the highest caliber, but is equally important in the training of undergraduate and graduate students. In the area of biotechnology, the differential in the median age of equipment is undoubtedly even greater. The influx of venture capital into the new biotechnology firms has enabled these firms to set up state-of-the-art facilities. It is vital that our students have training and the opportunity to conduct research with equipment of at least equal quality if they are going to be effective in the private sector.

Charles E. Hess, Dean, College of Agricultural and Environmental Sciences, and Associate Director, California Agricultural Experiment Station, University of California, Davis, California. Testimony before the U.S. House of Representatives Committee on Science and Technology, May 8, 1984.

An index of the need for equipment is found in the Department of Defense (DOD) initiative in instrumentation. DOD estimates that $1.5 to $2.0 billion would be required to elevate qualified academic laboratories to "world class" status in instrumentation. In response to the first year of a five-year $150 million program, DOD received 2,478 proposals totaling $645 million. Two hundred and four awards were made with each award averaging $148,000. That represents an award rate of 8% and a funding level 4% of the amount requested.

Space is also a critical limiting factor in the research infrastructure at many universities, both in terms of quantity and quality. An inventory conducted by the USDA in 1978 showed that there was a shortage of 1,110 scientist spaces equivalent to 15% of the scientific population in State Agricultural Experiment Stations. Renovation was needed to accommodate 1,249 scientists, or nearly 19% of the scientific population. At UC Davis, space is now one of the most important limiting factors in recruiting and retaining faculty and graduate students.

There has been great reluctance by federal and state government, the private sector, and foundations to become involved in the business of bricks and mortar. State appropriations often have been targeted to alterations or modifications to meet governmental regulations for fire, occupational, and seismic safety and for access for the handicapped. State funding for new facilities is driven more by student numbers than research needs. As we enter a period of declining college-age population, the role of the university in providing the basic research needs of the country must not be overlooked.

It is true that in some of the federal laboratories there is underutilized space. In one case with which I am familiar, the Western Regional Laboratory at Albany, California, the USDA is planning a laboratory to do research on gene expression in plants in collaboration with the University of California at Berkeley and Davis and with private laboratories in the Bay Area. However, such a facility, 65 miles from Davis, does not alleviate the space problems on the Campus.

A third limiting factor in the university research infrastructure is support personnel. Technicians are an invaluable assest in a faculty member's laboratory for the operation and maintenance of equipment, and to continue experiments for faculty when they must be in class or meeting their other university responsibilities. The increased sophistication and cost of today's equipment makes an expenditure in support personnel a wise investment.

A fourth factor affecting the university research infrastructure is the ability to attract young people to do graduate work. This is particularly true in engineering, but is also the case in the basic sciences, including plant biology. In the case of engineering, opportunities in industry for B.S. graduates are great enough that many bright, young people are choosing to go directly into industry rather than pursue graduate study or careers in the university.

The information explosion is placing a strain on a critical component of the research infrastructure of U.S. universities, the library. Space for books and journals is in short supply, and as a partial solution the University of California has constructed regional facilities to store infrequently used books. Electronic technology for the dissemination and handling of information may alleviate the problems in the future, but solutions for the current needs must be sought.

There is one other constraint in the U.S. research infrastructure which is also related to the information explosion. That is the transfer of new knowledge generated in the universities to potential users in society. The case is often made that while the United States is preeminent in basic research, other nations seem better able to translate new ideas into practice. One explanation is that the ties between universities and industry are not close enough. Some scientists feel that there is value in maintaining some distance between universities and the private sector, so that there is complete freedom of inquiry, free exchange of information, and full opportunity to do basic research without concern for direct application. However, others believe that the scientific community has a responsibility to not only create useful knowledge but also to evaluate it and present it in a form suitable for application. Later I will suggest a model which has been successful in agriculture and may be applicable to other industries.

In summary, then, the constraints to the research infrastructure in U.S. universities are: equipment, space, support personnel, graduate student support, and the ability to handle the information explosion and translate new information into practice.

What then are some of the options? In regard to instrumentation, I encourage enthusiastic support of the DOD program in instrumentation and the increased funding for instrumentation that has been incorporated into the NSF grants program. In the Foundation's 1984 budget there was an overall increase of 60% in instrumentation across the directorates, going from approximately $112 million in 1983 to $180.2 million in 1984. However, in view of the equipment needs that exists, as indicated by the DOD figures, expanded programs would be a wise investment. A particular challenge at the college or departmental level is equipping laboratories for new faculty. Neither the DOD nor the NSF programs meet this need. The DOD program is designed to fund large items of equipment ($50,000 or more) used by a number of scientists, and NSF grants to individual investigators are not intended to establish laboratories. The President's Young Investigator Awards Program conducted by the NSF is a model that could be expanded to meet this need.

Another approach to meet the needs for both equipment and research space is to reinstitute the Graduate Science Facilities Program in the NSF. From 1960 to 1972, the National Science Foundation conducted institutional programs to strengthen research and education in U.S. colleges and universities. In contrast with other NSF programs, which are generally geared toward individual research, there were institutional programs targeted to improve the quality of academic science on a scale at least as broad as a department. The Graduate Science Facilities Program required at least 50% matching funds by the grantee institution. This matching requirement was intended to stimulate the flow of state and private monies and to show evidence of local commitment to the program. Initially, the program emphasized renovation rather than new construction, and the installation of fixed equipment such as laboratory benches. As the program matured, however, restrictions on the use of the grant money was relaxed and permitted expenditures for general purpose laboratory equipment and for new construction.

The desperate need for facilities has led some universities to make "end runs" to Congress much to the concern and dismay of the scientific community. A program as I just described would give universities a viable alternative and would provide peer evaluation to help ensure that the best investment is made with public and private funds. Other agencies such as the USDA should be encouraged to develop similar programs. Although authorization for facilities was included in the 1981 Agriculture and Food Bill, funding has not been provided except for the 1890 Land Grant Colleges.

Universities also have a responsibility to ensure that equipment is used efficiently. A successful approach at the University of California, Davis Campus has been the establishment of the Center for Advanced Instrumentation. The Center serves as the home for major pieces of equipment which can be used not only by faculty at Davis, but by scientists from other universities, or by the private sector on a recharge basis. The Center is staffed with personnel overseeing the operation and maintenance of the equipment. A portion of the user fees can be used to help replace obsolete equipment.

The Office of Technology Assessment suggested in its report on Commercial Biotechnology--An International Analysis, that as an option to meet the training needs for biotechnology, Congress increase funding for USDA, NIH, and NSF graduate and postdoctoral training grants in plant molecular biology, applied microbiology, and bioprocess engineering. This same approach should be considered for all areas of science and engineering in which there is a shortage of trained individuals to meet the needs of the universities and the private sector, and to be sure that we continue to attract the finest minds to U.S. research.

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Mr. MacKay [acting chairman]. Thank you, Dr. Young and Dr. Hess. We would now like to ask some questions or perhaps make some comments.

Mr. McCandless?

Mr. McCandless. Thank you, Mr. Chairman.

Well, as a graduate of your institution, Dr. Young, welcome to the sunny area of Washington, D.C.

Dr. Young. Thank you very much, Mr. McCandless.

Mr. McCandless. I won't tell you how long ago I was there, but there were 15,000 people on the campus and we considered it the factory and there was a big gully that went down through the center of it.

Dr. Young. I can place the time fairly well.

Mr. McCandless. I have two areas of concern or interest. The first would deal with curriculum, and the second facilities, and then third—particularly to the University of California—the university structure and the campus aspect.

Under curriculum, it has been my observation that the interest in a given discipline, such as engineering or medicine, appears to be in direct proportion to how you can merchandise that on the outside, either as an individual or the demand. We have had peaks and valleys in this historically and, as such, then it would appear that at the university level our capital structures and our resources do not necessarily reflect that peak-and-valley type of scenario, which then would mean that the system becomes inefficient because you plan, and the fact that you plan and the best of plans seem to get set aside based upon the realities of this thing.

How can we better address the loss of that resource in these fields due to these peaks and valleys, simply the law of supply and demand on the outside?

Dr. Young. Mr. McCandless, you have certainly pointed to a very pervasive problem. Certainly it is not only a problem of universities; it is a problem in planning generally. We have tried to even those peaks and valleys out to the best extent we can. I think that is one response. When there was a falloff in demand for engineers a number of years ago, we reached the conclusion that that was a temporary valley, that we are going to get back to a peak, and we should do everything we could to even that out and not have that valley and peak occur within the university, and therefore maintain support for engineering. We tried to maintain not only the facilities but to maintain the faculty, so that we were able to pick back up when the demand hit, and the demand did hit again, but we were not able to build for increased demand that has come along subsequently. We were not able to project that increased demand as well as we should.

But I think one of the things we have to do in the universities, and certainly we can do that, I think, in a system like the University of California perhaps a little more than some, because of the size and flexibility we have with a variety of campuses, is to see to it that we are meeting the needs not only of today, but the future as best we can determine them. I see no other alternative. I pointed out one of the problems in my comments, and that is that facilities unfortunately are not fungible. We can't use the facilities that might be excess in the Department of Classics to help at the present time with the problems that we have in biology, so we have to do the best job we can to try to plan for the future and then try to maintain some stability within the university. We can do that at UCLA because, for instance, within the system we can hold the enrollment levels constant because demand is much greater, so we can, I think, provide that kind of stability, but it is not an easy task.

Mr. McCANDLESS. The second area is facilities, and my question then would deal with this: We have in California what I think is an outstanding community college system, for particularly lower division and vocational work. If we were to encourage these institutions, which in many cases have surplus facilities, to take our basic undergraduates, lower division, wouldn't that relieve some of the existing facilities in the universities for the upper division and graduate work, which then would better utilize those facilities?

Dr. YOUNG. Yes, of course, Mr. McCandless. That is the whole basis on which the master plan for higher education in California was founded, the assumption that a very large proportion, at least, of the lower division education was going to be accomplished at the community colleges.

For a long period of time that did occur. A variety of changes have developed in the last few years which have resulted in a substantial modification of that, and I believe we need to work together—that is, the university, the State colleges and universities in California, and the community colleges, along with the other State agencies and the legislature—to try to restore that balance. But at the present time there really is not any substantial surplus of facilities even in the community colleges, so that the problem I don't think can be dealt with to any considerable extent in that regard, that is, the facilities problem. But I believe regardless of that, that we need to get back to that more balanced approach upon which the whole master plan for higher education in California was based.

Mr. McCANDLESS. Did I detect a bell there, Mr. Chairman?

Mr. MACKAY. Yes, but I am not a very formal presiding person, and Dr. Hess indicated that he would like to also respond so, without objection, we will proceed.

Dr. HESS. Thank you, Mr. Chairman.

Mr. **McCandless**. The other side of the aisle tends to be flexible from time to time, Doctor.

Dr. **Hess**. Mr. McCandless, I had two issues in terms of the community colleges. One of the problems is that the community colleges are not training as many college-bound students as they had in the past, and have gone more into bread-and-butter courses. I remember driving past the Sierra Foothills Community College, and they had a special course in brickmaking. I think part of that has been the economy. They have attracted students, older students, senior students actually in terms of courses of that nature, rather than the college prep courses which were not returning to them the funds that they needed.

The other aspect is that in terms of facilities, however, I am not sure whether even if we are able to get a better balance, as Dr. Young has mentioned—which I think we definitely should try—whether that will alleviate the space problem, because in the lower division courses there are many of the basic courses in math and chemistry and physics, and it is when you get into the upper division courses where you really get the students into the more sophisticated laboratories where they can actually do experiments themselves. I think that that is where our real crunch is in terms of quality, state-of-the-art equipment.

Mr. **MacKay**. Thank you.

Mr. Mineta.

Mr. **Mineta**. Thank you very much, Mr. Chairman.

I, unlike Mr. McCandless, come to ask questions because I am being purely objective. I am neither a UCLA graduate nor a Davis; I am Berkeley, so I am purely objective on this whole issue and have come with no prejudices. [Laughter.]

Dr. Hess, let me ask, on page 3 you are talking about the conflict between the ties between the universities and the industries. Some say it is too close; some say it is that they aren't working closely enough to be able to have this technology transfer and the application of it in the private sector.

You have had to go through a controversy up there involving tomatoes, I mean, the whole tomato-picking machine thing. Just using that as an example, how do you relate that to this conflict between the two, let's say, extremes here of some saying it's too close and some saying it is not being coordinated well enough?

Dr. **Hess**. Well, I think my own feelings on this issue are that a close university-industry relationship I think is essential for the United States. I think that it helps insure the relevance of research that is being conducted. It insures the more rapid translation of those research findings to use for the benefit of society; and oftentimes it will provide opportunities for students for internships and on-the-job training to better prepare them for their careers.

In this particular example that you have cited, with the suit brought by California Rural Legal Assistance and their concerns that the private sector with small investments of funds supporting research, leverage the balance of the public funds in setting research priorities, I don't agree with that viewpoint. We have our policy on the campus that we will not accept funds from the private sector unless it is in support of a previously approved research project, so there is an opportunity to evaluate that project at the departmental level and in our office. Since we are associated with the Department of Agriculture, most of our projects are also reviewed by the U.S. Department of Agriculture before they are implemented. So I think we do have that protection but maintain, I think, a very valuable linkage.

I think that we are what I would call a more mission-oriented college, in that our research is funded in part by the State to benefit agriculture, environmental issues, the consumer. There are components in our college which are what I would put at the end of the continuum of basic to applied research in biochemistry, biophysics, genetics, and so forth, and those scientists should have the environment in which they can follow their initiatives, follow their abilities to discover new knowledge which then can be translated eventually into application. That's the sort of continuum that I see as being very beneficial for the university, going from very fundamental research to the application of that research in the private sector.

Mr. MINETA. Now in trying to evolve toward, let's say, the formulation of some kind of an industrial policy, many people say we ought not to be doing that because that means someone has to be picking winners and losers. I mean, that is the rhetoric right now. How do you protect yourself from the charge of having to prejudge something in terms of picking winners and losers, as to how you direct your research efforts, especially if you tie that in with Dr. Young's suggestion that the infrastructure amount ought to be dependent on whether or not—I take it that it ought to be tied to a specific research project?

Dr. HESS. We don't actually try to pick winners or losers. Problems are brought to the faculty through Cooperative Extension, through advisory groups, and if we feel that it is a researchable problem, a problem that would lead to the creation of new knowledge and it would be appropriate for the university to conduct, then we will conduct it. Whether it wins or loses depends upon the success of the research, so we don't make a judgment initally as to whether that area will be successful or not. We try to base it on what we view as the critical research needs for the State.

Dr. YOUNG. Mr. Chairman, could I make a brief response to that? I won't go into the details because of the time limitations, but I believe that this problem that you identify in general—and you have looked at it from two sides, Mr. Mineta—has been given more serious attention over the last 2 years in our university and in universities across the country than any other single problem. I believe that we have done a great deal to make certain that the policies which existed, to the extent they needed modification, have been changed, looked very carefully at the problems which could be created from application of that relationship in an inappropriate fashion, and the potential difficulties which I think needed to be examined 2 years ago have not now been totally resolved, but I believe we have gone a long way toward seeing to it that we have a structure in place which enables us to deal much more efficiently at that interface between business and industry than we were 2 or 3 years ago.

Mr. MINETA. If I might, Mr. Chairman, part of the criticism of the selection of the present chairman of the board of regents was that his connection with the private sector was not going to be helping the university's efforts to get funds, whether it be for research or for capital projects. Frankly, I was stunned and taken aback by that approach by that individual at the time of the controversy, and that is the criticism that comes up about how close the connection is between the private sector and the university community about the research efforts.

Dr. YOUNG. Mr. Chairman and Mr. Mineta, I was equally, perhaps more stunned and upset by that attack than you, so I am not defending the attack, but it was not I think—because I was sitting there listening to it—directed at the kind of relationship we are talking about here, but at the more traditional relationship of fundraising from the private community, not business/industry relationships to research output and the interface of technological change, but more to whether or not he was a person who was going to be as effective.

I think the argument was ridiculous. I don't think the chairman of the board operates in that area, but it was more to the general relationships with the business community in raising funds for the university, not in the research technology interchange.

Mr. MINETA. You're right, Dr. Young, I wasn't there, but frankly that kind of mentality on the board and people of that ilk we don't need, as far as I am concerned.

Dr. YOUNG. Mr. Mineta, I agree completely with that. I just wanted to point out that I don't think it was related to this particular issue.

Mr. MINETA. Thank you very much, Mr. Chairman.

Mr. MACKAY. Mr. McCandless?

Mr. MCCANDLESS. Thank you, Mr. Chairman. I have one more area that I wanted to cover here, and the chairman has been kind enough to give me additional time. I think it is important because the University of California, with all of the campuses it has, is an example of the area that I want to cover and the answers that I would hope we can get from that.

With the type of multicampus structure that you have and the sizes of those campuses, and the amount of research programs and effort going on on these various campuses, how is all of this coordinated? Are we duplicating areas that, if you had more of a clearinghouse, you could eliminate and therefore those resources—be they governmental, public, or private—would find more bang for the buck? Either one of you, whoever has a thought on it.

Dr. YOUNG. Well, I think the answer is yes and no to that, Mr. McCandless. There is some coordination and there is some specialization. You have before you an example, at least, in Dean Hess. Agriculture is concentrated in one or two or three, essentially three of the campuses, and agriculture itself is distributed in an uneven fashion among those three campuses with concentration of different sorts in each. You are very much aware of the Riverside campus' program.

There is a real difference in the specializations in the sciences between Berkeley and UCLA. We do not try to duplicate the very heavy nuclear physics programs at Berkeley but, instead, in physics have moved in different directions and tried to establish different strengths. Generally speaking, that kind of an arrangement exists among the several campuses in other areas as well.

They are, however, each of the campuses in the University of California is a general campus and has the mission of providing an education both at the graduate and undergraduate level for students in all disciplines. The specializations, therefore—with one or two exceptions such as agriculture—the specializations, therefore, have to be at the fringe, really, and not dramatic differences among the campuses in terms of their basic mission. We've got that large a job to do and it would be impossible to divide it up, I think, so that there was no duplication at least in the basic areas.

Dr. HESS. The other, we do have in agriculture a vice president for agriculture and natural resources, and we do meet quarterly to discuss research needs and policies. I guess there is now also a vice president for medicine and the health sciences, and that would provide I assume some degree of coordination there.

But the other aspect is that, given our system—particularly the peer review system, in which faculty are evaluated in part by their ability to publish new knowledge in peer review journals—there is a tremendous drive not to duplicate, because if someone finds something and publishes it, then that closes out that area unless there is confirmation or a different point of view, which I think then is healthy duplication, if you will. It is not going over to provide, you might say, authentication of the findings. As you hear, issues come before the scientific community, differences of opinion, and it needs to be replicated by other workers to be sure that, in fact, those findings are valid.

So, two issues, then: One is that I think there is quite a peer pressure, you might say, to avoid duplication, to find new knowledge or new insights, and that which does exist I think is important to insure that we get validation of new findings.

Mr. MCCANDLESS. One other quick point, if I may. I would like to be hypothetical. Mr. Mineta can relate to this. Let's say that the Federal Government says: "Well, University of California, you are in pretty good shape here. We want you to do some research on the Mediterranean fruit fly." How does that fit in? What is the entry location within the university structure for that? Then, how is that distributed? Somebody says: "Hey, we've got the test tubes and we've got the instruments at Berkeley," or "We've got them at Davis," or someplace, how does that take place?

Mr. MINETA. Would my colleague yield for just a minute?

Mr. MCCANDLESS. Certainly.

Mr. MINETA. I'm sorry. Was that part that I would be more related to the Mediterranean part or the fruit fly part?

Mr. MCCANDLESS. Well, my distinguished colleague has all kinds of ways of making that assertation.

Dr. HESS. Mr. Chairman, the way that would work is, the vice president for agriculture and natural resources would be contacted or one of the deans on the three campuses would be contacted and told, "Here is a problem." In this particular case we did respond to it, for example, by conducting research and developing better attractants to establish traps which could more accurately determine when there were fruit flies in the area.

Also, we did research on what was the impact on the communities from the aerial spraying, a number of different areas of——

Mr. McCandless. That was assigned, then, to your campus by this committee?

Dr. Hess. It was assigned both to our campus and to the Berkeley campus. Berkeley has a group in biological control, and we were working on the sex attracting or the trapping of the fruit flies.

Mr. McCandless. The reason I mentioned Mr. Mineta, Mr. Chairman, is that is where the problem started, in his district.

Mr. Mineta. Not with me, but within my district.

Mr. McCandless. Yes; in the district. Yes.

Thank you, Mr. Chairman.

Mr. MacKay. I would like to make an observation or two and then ask some questions.

My perspective is slightly different, in that I spent 12 years as a member of a State legislative body and have worked on some State/regional compact groups having to do with higher education and research. It is widely agreed at the State level that the erratic support by the Federal Government for research has been a major part of the problem over the years, first in causing the universities to overexpand and then, as both of you have pointed out, leaving you with facilities and inadequate funds to support the facilities, under the assumption that the States would pick this up, with the States being already overstressed in their financial support.

Now, finding ourselves at a time when we are increasingly in international competition, where our ability to compete is related to the ability to innovate, which is related to R&D, and having it not clear what the Federal role is going to be this time, I would like you to comment perhaps more specifically, Dr. Young. It seemed to me that what you have said is, if we could have everything we wanted this is how it should be. Now I would like to pose to you the question: Suppose you can't have everything you want, and suppose there are going to be more and more stringent limitations on Federal dollars, what is the best way for the Federal Government to support research in the university system? Would it be best to support it with instrumentation, with a constant level, or is a one-shot upgrading the best? Or, when you talk about facilities, do you mean bricks and mortar as opposed to instrumentation? What is the best way for the Federal Government to support research, with the understanding that each State university system is different and that the Federal Government probably is not going to be able to redesign all the university systems?

Dr. Young. Mr. Chairman, I believe that you have put your finger on one of the real problems, and that is the inconsistency: Moving from very heavy support to a period of very little support and, in effect, leaving an apparatus which is in place and needed without the resources to sustain itself, so that one of the very important aspects that I believe should be taken into account is the necessity to maintain a consistent level of support. I believe it really has to be across the board and I think it also has to, as a part of being consistent, have a long-term quality. I don't believe that we need a quick fix. I believe we need recognition that, if research is going to be done which is going to be in the national interest and is going to provide us with the ability to maintain the graduate educational program in science and technology, that you have to have facilities to support students, you have to have the facilities to support faculty, and you have to have the buildings in which that occurs and the instrumentation which is required. I believe it is all of those things.

Now, obviously that is not all of the kind of need which I have identified, for instance, as existing within the University of California at the present time; it is not all a Federal responsibility, but some portion of it—and, I think, that that is very closely related to the research which is federally supported—is the appropriate share for the Federal Government to take.

Mr. MACKAY. But if there is only a specific, finite amount of funding available, are you suggesting that we should cut research funding in order to more adequately fund facilities?

Dr. YOUNG. I believe that, in the long run, we are going to have to find some way to see to it that the support which is granted for research carries with it, through one mechanism or another, support for equipment and for facilities, and I guess I would be saying then we need to see to it that we are providing support across all those functions. If there is an inadequate amount to meet all that need, then we ought to do the best we can to try to provide support across those several areas.

Mr. MACKAY. Would you, then, be saying that there should be a retrenchment and that the Federal Government should more clearly define its areas of interest, and what research it supports, it should support adequately? I am saying, given the premise that we can't keep doing everything, but part of the background of my comments is, we right now are, I think, in the worst of all worlds. That is, we are basically robbing civilian research to run a broadening military research program, and we are pretending that there is no cost to that in the areas of civilian research which have to do with our international competitiveness. It seems to me people are not willing to face that. Dr. Keyworth doesn't really address that directly in his testimony, articulate though it is. He just doesn't see the issue in that fashion, and I am saying somebody has got to start talking about that.

One of the problems I think you face in California, as we face in Florida—although this doesn't have to do with fruit flies—is that we have overexpanded. We have overexpanded our university system, and now we are having trouble politically trying to figure out whether we should allow Gresham's law to work and keep everything we've got but not fund it, or whether we should begin to concentrate on the question of quality. That is the kind of question I'm asking you.

Dr. YOUNG. Mr. Chairman, to go to the question you asked specifically, I believe that the Federal Government ought to support the programs that it supports in a sufficient manner for the job to be done properly.

Mr. MACKAY. Now, what is your position on the question of the end-run problem as it affects the Congress, that is, the universities or specific programs to come here and lobby for their own interest instead of continuing to work through professional groups and the AAU?

Dr. **Young.** I believe for myself, Mr. Chairman, and as a member of the associations to which I belong and speaking for the University of California, that the end-run approach is potentially very destructive of the relationship between universities and the Congress and the Federal Government, and we must find ways to provide those facilities without coming directly to Congress for funding specific research facilities.

Mr. **MacKay.** All right.

Dr. Hess, would you have any comment?

Dr. **Hess.** I think that the question of funding, whether it be for students, individual researchers, or for equipment, has to be looked at from the standpoint of that if any one part of the infrastructure is shorted, that affects all parts, and we have gone in the past through a period in which funding of equipment was not entertained. That has now been changed, and I think that is a very important step in the right direction, so I think that it's difficult to say we'll shift within that infrastructure from one area to another.

I think the concept of having matching funds is one way to be sure that there is a commitment from the local level and the State level as well as there is from the Federal level, and to do it through a program which has a peer review component I think will also help insure that that is the best investment, that is, that the funds do go to institutions that have the quality to do the research.

Mr. **MacKay.** Are you suggesting, Dr. Hess, in your comments about the extension service being a good model, perhaps, for more rapid diffusion of research results, are you suggesting that your agency should broaden its role or that another agency should, that there should be in effect an engineering or a science extension service?

Dr. **Hess.** I am suggesting the latter, that the model that has worked, I think, very well in agriculture should be explored to see if it would have applications in engineering. I don't see the agricultural Cooperative Extension Service taking on the engineering component. That would be completely improper, but I think the model has some very interesting aspects and, I think, has made real contributions in agriculture. I wonder, since the observation has been made that we do seem to have a problem in terms of translating information to use, if that could be one approach.

Mr. **MacKay.** All right. Would you favor more of a block grant type funding, where in effect the Federal Government gave to each State a sum of money and allowed the States to make the priority decisions in where the money went for research, or would you favor it continuing now as it now exists?

Dr. **Young.** I think that, as I indicated in my statement, that there are several mechanisms which ought to be explored very carefully. At the moment, I wouldn't be prepared to say that I think one of them is a better approach than the other. I suspect that we will finally conclude, when we look at them together, that we need to have more than one method of accomplishing this. I think the block grant might be a useful method, to a limited extent. I think on the other hand, though, the funding of facilities through the agencies that are sponsoring research in order to provide the facilities to enable them to get their research accomplished is also a very important way, and I wouldn't want to at the present time choose between those two or among several others that might also be applied. I suspect those are probably the two ways, however, which would together make the greatest impact in resolution of the problem we have at the present time.

Mr. MacKay. Are there any other questions, Mr. McCandless?

Mr. McCandless. No.

Mr. MacKay. This has been very helpful, and I appreciate your being here. We regret that our weather has caused the problems with Dr. Rhodes and Dr. Silber. Without objection, the statements by Dr. Rhodes and Dr. Silber will be inserted in the record, and the record will remain open for Members to submit other material in the record until May 15.

Thank you very much for being here, and we are adjourned.

Dr. Young. Thank you, Mr. Chairman.

[Whereupon, at 10:55 a.m., the committee recessed, to reconvene at 10:57 a.m., the same day, for the purpose of hearing a statement from Dr. Rhodes.]

Mr. MacKay [acting chairman]. If it is possible to do so, I would like to reconvene the meeting so that we could hear from Dr. Rhodes. I very much appreciate the problem that he has had.

Dr. Rhodes, if it is convenient with you, we will go right ahead with your testimony. We appreciate your being here and apologize for our weather.

STATEMENT OF DR. FRANK H. T. RHODES, PRESIDENT, CORNELL UNIVERSITY, ITHACA, N.Y.

Dr. Rhodes. Mr. Chairman, I apologize to you for being late. I have just driven by the scenic route from Hagerstown, and I apologize to you and members of the committee.

My name is Frank Rhodes, and I am the president of Cornell University. I have the pleasure this morning of representing the 50 major research universities of the Association of American Universities, as well as the American Council on Education and the National Association of State Universities and Land Grant Colleges, and the two Associations of Graduate Schools.

I begin from stating what you and your colleagues know so well, which is that the research and development base which our Nation has created over many decades remains the strongest and the most productive in the world. But in spite of that strength, there is evidence now that the gap between us and our foreign competitors is narrowing, partly because of their increased investments in science and technology and partly because of the erosion in our own research base.

In spite of recent increases in funding for research and development, the basic research component of those increases has been modest, and we now face very serious problems in the Nation's universities with regard to our basic research effort. It is those problems that I want, with your permission, to address and to identify, especially those in graduate education, the case of young research workers, research instrumentation, and research facilities, and then in response to your request to say a little about overhead costs and the appropriate Federal role in fostering university and industry partnerships. I will be very brief, in view of the fact that you have generously reconvened, and hope, Mr. Chairman, that you will accept the full written account for the record.

First of all, our graduate schools: They provide the continuing supply of trained individuals with the skills on which our future depends, but we now face a very serious shortage of graduate students in certain fields. For 15 years, Federal support for graduate education has been substantially reduced and the number of federally funded graduate fellowships in the physical sciences and engineering has declined from 51,000 in 1968 to about 1,500 today. In the face of sharply increasing international competition, critical national needs covered by graduate education are now going unmet.

The present administration has proposed small and highly targeted increases in university research and development, especially in those areas perceived to be of closest significance to the national defense. Let me illustrate the budgets of three agencies—the NSF, DOD, and NIH—which show, I think, the limitations that our universities face at present in terms of Federal support.

The Department of Defense budget proposes to increase its investment in university research at a level slightly above inflation, and to award the third class of 40 graduate fellowships designed to attract graduate students into programs linked to our national security needs. They also propose to undertake a 5-year, $150 million program to upgrade research instrumentation in labs that carry out research programs in areas related to defense needs. But, as you and your committee members know, the DOD research initiatives—commendable as they are and welcome as they are—are now at risk at present in the House version of the DOD authorization bill for the coming financial year.

If we turn now to the National Science Foundation, the 1985 budget outlook is much more encouraging. Augmented in the House authorization bill by the increases proposed by your committee, this provides for significant real increases in the Foundation's physical sciences, engineering, and graduate fellowship programs, with other more modest increases in other fields. This NSF budget is the centerpiece of the administration's financial year 1985 budget for university research, and I want to express to Dr. Keyworth and his associates—as well as to you, Mr. Chairman, and members of your committee—the appreciation that all of us, in the research university community, feel for your leadership, not only in strengthening that NSF budget but in negotiating it with such skill through the passage of the authorization bill. We regard these as welcome and important first steps toward a more comprehensive Federal investment strategy to strengthen basic science and graduate education.

In sharp contrast to that, we note with real concern the lack of any significant funding increase in NIH research activities. In fact, the budget request for NIH and ADAMHA is once again below the levels needed even to sustain the present research activity, and our hope is that members of this committee and the Congress will again support efforts to protect and sustain university biomedical research and training programs.

There still remains, then, the urgent need to attract some of our outstanding young people into science and technology, and the new competitive fellowships offered by the Office of Naval Research are an excellent model for other agencies. Our hope is that other Federal research agencies will follow the lead that they have given, providing a total of some 750 or so merit-based portable graduate awards to individuals and an equal number of awards given to students through institutions with high-quality graduate programs.

Second, let me mention the plight of young faculty, newly-appointed in universities and now facing increasing problems because of the inadequacy of facilities in which they have to work. The support of young faculty has been recognized by the National Science Foundation with the Presidential Young Investigator Awards program, and we hope that that will be continued at least at its present strength, not only by the National Science Foundation but, again, that other agencies will follow the lead that they have given.

Point three, research instrumentation: Instrumentation and equipment now being used in many of our university research and training labs is very seriously out of date. A recent survey just published by the National Science Foundation illustrates the extent of the problems that we face. One fourth of our research equipment, with a total purchase price of $904 million, is now obsolete. Only 16 percent of all the equipment in academic research labs is state-of-the-art. Ninety percent of our departmental chairpersons reported in the survey that the lack of equipment inhibited the conduct of critical research.

These new National Science Foundation data amply justify increased investment by the NSF and other major mission agencies in university research equipment, but that alone will not solve our problems. We have to look for additional and alternative solutions to make sure that scarce resources are fully utilized. That's why we applaud the efforts of the AAU, the National Association of State Universities and Land Grant Colleges, and the Council on Governmental Relations to undertake a comprehensive study designed to explore alternative sources of funding for research equipment. That project is supported by six Federal agencies.

Let me turn now to research facilities, and to say again that the needs here are equally pressing. A recent survey by the NSF of 25 universities estimates that research universities and colleges require at least $1.3 billion per year to meet accumulated research facilities needs, and yet the total Federal investment in R and D plant in universities is projected to be $40 million in 1984, and essentially all of these funds are targeted for special purpose user or national facilities. There is no general reinvestment effort by NSF or by any other mission agency designed to help with the modernization of the university research labs in which so much of the agency funded research is carried out. This, I have to emphasize to you and the committee, Mr. Chairman, is our most serious long-range problem in the research universities.

You suggested that I might illustrate what I have to say by experience at one university—my own, Cornell—and I am happy to do that to show the local magnitude of the problem. We are proud to be among the Nation's leading research universities, with a total in the last fiscal year of about $150 million in sponsored research. NSF and NIH are the major sponsors. Let me illustrate, with half a dozen very brief snapshots, the problems that we now face.

The first is university libraries. Universities deal with knowledge: We make it, we transmit it, we store it, we use it, and the effective storage and dissemination becomes a growing problem with the exponential growth of new knowledge. Computers can help here, but our library of more than 4 million books can be computerized only at a cost of $6 million in front-end funding and an additional $1 million a year in operating costs. There is little likelihood that that long-term cost will decrease.

Second, we operate, with NSF funding, a materials science center, the largest of 14 such programs throughout the country. It has existed for 25 years and contributes significantly, through research and highly trained personnel, to the Nation's economy and the study of the uses and properties of material that affect every aspect of our life. We have put a high priority in our internal funding on replacing equipment—capital items—devoting 15 to 20 percent of our budget a year for that particular need, but the cumulative deficit we now face in equipment for that facility is $4 million, and without it our value as a research and teaching resource is compromised. We have no source to which we can turn for these funds.

Item three: We operate a very successful national submicron facility in support of computer chip development. It is the only center of its kind supported by NSF. It was built by Cornell with private funding, and it is funded jointly by NSF and the semiconductor industry. In this area we face an immediate shortfall of $5 million for new equipment over the next 3 years. If we are to remain competitive in the international field, we must have equipment that is state-of-the-art.

Item four: The problems of new faculty members requiring new labs and new equipment are particularly pressing on the Nation's research universities. We appoint 20 to 25 young scientists every year to our faculty, and we find that the cost of equipping them lies between $100,000 and $300,000 each. To the extent that we are unable to provide the best possible start for these young faculty members, we limit their growth and their usefulness.

Item five, new facilities: I have mentioned this in national terms. At Cornell we see a focused example of it. We have great expertise in such areas as biotechnology, in plant and molecular biology, in animal reproductive biology, in electrical engineering, in computer simulation, and a host of other areas. Our cumulative needs in terms of facilities well exceed $100 million. We have no immediate hope of obtaining those funds.

Let me turn to two items, Mr. Chairman, about which you made particular inquiries. The first is indirect costs. For the past 2 years we have seen increased attention paid to indirect costs, not least because in financial years 1983 and 1984 the Department of Health and Human Services proposed cutting reimbursement of indirect costs by 10 percent. Universities complained loudly, and the result of that was that the proposal is no longer part of the administration's fiscal year 1985 budget, and the President's science adviser has proposed a study of the issue of indirect cost in the context of the universities' ability to continue to undertake federally sponsored research.

I won't go into all the reasons for increases in indirect costs. My written testimony covers this in some detail, but there are two fundamental reasons for the increase. The first is that we face increasing Federal regulation in the way in which we conduct research and also, with it, federally instituted requirements for detailed cost accounting. The second is, inflation disproportionately affects indirect costs for various reasons in terms of the purchase of equipment and the maintenance of equipment.

It is important, I think, to remind ourselves that indirect cost rates are always approved retrospectively, in very detailed discussions with Federal auditors who continually monitor and examine university expenditures.

Finally, you asked me to address the question of what the Federal Government can do to increase the pattern of cooperation between the universities and industry. Industrial support of university research is one of the most significant developments of recent years, but it can easily be overstated. The total industrial support for university research is now only about 3 percent of all funds used, and few observers believe that it will ever rise beyond about 8 to 10 percent of the total. For most universities undertaking research on a major scale, it is not in fact a new phenomenon. It has existed for decades.

You have encouraged, for which we are grateful, a variety of funding mechanisms and cooperative agreements which are still being developed. Often, the award of an equipment grant from the National Science Foundation or other agency is proving to be a very important catalyst in the development of these new arrangements with industry, so an important side benefit of Federal investment in research equipment is the stimulation it gives to new research partnerships between industry and the university.

One of the most significant incentives that you have offered is to develop the donation of research equipment to universities, and I speak specifically of the Economic Recovery Tax Act of 1981. That ought to be strengthened, we believe, to provide for the donation of instructional equipment or equipment previously used by the donor for less than 3 years, and to remove some of the present ambiguities over the donation of computer software. We find that tax incentive especially valuable for large corporations, but we hope that you can also review the need to develop incentives for small, innovative companies. Different kinds of stimuli are probably needed to assist them in the development of sophisticated new instrumentation.

University research has special requirements for this kind of instrumentation, and we believe that university faculty can play a useful role in assisting small companies to meet the difficult challenges involved. We need to find new ways to encourage that kind of cooperation.

In concluding, Mr. Chairman, let me say what your committee does not need to be reminded of but which perhaps others in Washington may need to hear repeated. Research is the foundation of our national progress. Our economic strength, our industrial productivity, our cultural vitality, our people's health, our international leadership, and our national security—all these and more depend on it. With a strong research base—governmental, industrial, academic—we shall prosper. Without it, we shall decline. To neglect the research enterprise is to mortgage our future.

Alfred North Whitehead once declared many years ago, "The Nation that undervalues trained intelligence is doomed." That judgment stands. Time has reinforced rather than weakened its truth. Federal support of trained intelligence and its application in creative research and vigorous development is not simply one claim amongst many other competing claims, however admirable and worthy their goals may be; it is the prerequisite for all other goals. It is the best hope for their achievement. It is the foundation of their eventual implementation, the basis of our national well-being.

Mr. Chairman, that is why these hearings have raised questions of such major importance. Our present responses to them will influence our national life well into the next century. We wish to commend and to thank you and members of your committee for raising these fundamental issues.

Thank you.

[The biographical sketch and prepared statement of Dr. Rhodes follow:]

September, 1983

FRANK H. T. RHODES

Frank H. T. Rhodes is the ninth president of Cornell University. He was elected on February 16, 1977, took office on August 1, and was inaugurated in formal ceremonies on November 10, 1977, all in the University's 113th year. (Cornell was founded in 1865.)

A geologist by training, he holds the faculty rank of professor of geology and mineralogy at Cornell.

Before assuming the Cornell presidency, Rhodes was vice president for academic affairs at the University of Michigan for three years. He joined the Michigan faculty as professor of geology and mineralogy in 1968, and, in 1971, was named dean of the College of Literature, Science and the Arts, the largest of Michigan's 18 schools and colleges.

Rhodes was born October 29, 1926, in Warwickshire, England. He received a bachelor of science degree with first-class honors in 1948 from the University of Birmingham, England, followed by a doctor of philosophy degree and a doctor of science degree from the same institution. His honorary degrees include LL.D.s from the College of Wooster and Nazareth College of Rochester, L.H.D.s from Colgate University, The Johns Hopkins University, Wagner College, Hope College, and Rensselaer Polytechnic Institute, a D.Sc. from the University of Wales, and a D.Litt. from the University of Nevada at Las Vegas. He is an honorary member of Phi Beta Kappa.

He went to the University of Illinois in 1950 as a postdoctoral fellow and Fulbright scholar. From 1951 through 1954 he was a lecturer in geology at the University of Durham, England.

He returned to the University of Illinois as an assistant professor in 1954, was named associate professor in 1955, and became director of the University of Illinois Field Station in Wyoming in 1956.

Rhodes then went to the University of Wales, Swansea, in 1956 as professor of geology and head of the geology department. In 1967 he was named dean of the faculty of science there.

He has received numerous awards, including the Daniel Pidgeon Fund, Lyell Fund and Bigsby Medal, all from the Geological Society. He was the Gurley Lecturer at Cornell in 1960 and director of the National Science Foundation-American Geological Institute First International Field Studies Conference in 1961.

Rhodes was National Science Foundation senior visiting research fellow at Ohio State University in 1965-66 and Bownocker Lecturer there in 1966.

Since 1962 he has been editor of the geology series of the International Library of Science and Technology.

Rhodes is a member of the Geological Society of America, American Association of Petroleum Geologists, Society of Economic Paleontologists and Mineralogists, the Paleontological Society, the Palaeontological Association and the Palaeontographical Society. He was chairman of the International Conodont Symposium in 1970. He is a Fellow and has served as a council member of the Geological Society of London. He has also served as vice president of the Palaeontological Association, and Section C of the British Association for the Advancement of Science.

He served as external examiner to the University of Bristol, Belfast, Oxford and Reading and, for advanced degrees, to various other universities in Australia, India, the United Kingdom and Canada. He was an official visitor, traveling as a representative of the British Council, to universities in Australia, Pakistan, India, Turkey, Iran and Malaysia. He was also an Australian Vice-Chancellors' Committee Visitor to Australian universities. He has first-hand experience with universities in Germany, France, Sweden and Belgium as well as many in North America.

Rhodes has served as chairman of the curriculum panel of the Council on Education in the Geological Sciences. He has also occupied various positions in British governmental bodies including membership on geology and geophysics subcommittees of the Natural Environment Research Council (NERC), and the Board of the Geological Survey. As a member of the NERC's Earth Sciences Committee, he was involved in the over-all direction and long-range planning of government research and development in the United Kingdom in geological survey, natural resources, conservation and overseas aid programs.

Rhodes has served as a member of the Michigan State Board for the Humanities, university accreditation review panels for the North Central Association of Colleges and Schools, and as a director of the Southeastern Michigan Science Fair.

He is a former member of the Smithsonian Institution's advisory research committee. He is a present member of the board of trustees of the Carnegie Foundation for the Advancement of Teaching, the Gannett Foundation, a member of the Board of Overseers of the Memorial Sloan-Kettering Cancer Center, and a member of the Board of Directors of The Continental Group, Incorporated.

He is the author of over 60 major articles and monographs and five books. Among his publications are Evolution, Fossils: A Guide to Pre-Historic Life, Geology, The

Evolution of Life, and Language of the Earth. He was the senior author of the monograph on undergraduate education published by the American Geological Institute in 1971.

Rhodes has been author, consultant and participant in several educational radio and television programs, including the British Broadcasting Corporation (BBC) television series "The Planet Earth" and the BBC radio series "Science, Philosophy and Religion."

Rhodes, a naturalized United States citizen, and his wife, the former Rosa Carlson, of Iron Mountain, Michigan, have four daughters. They live at 603 Cayuga Heights Road, Ithaca.

STATEMENT

before the
Committee on Science and Technology

U.S. House of Representatives

by

Dr. Frank H. T. Rhodes
President, Cornell University

on behalf of the

Association of American Universities
National Association of State Universities and Land-Grant Colleges
American Council on Education
Association of Graduate Schools
Council of Graduate Schools

May 8, 1984

Mr. Chairman, Members of the Committee on Science and Technology:

My name is Frank Rhodes, and I am President of Cornell University. I have the pleasure this morning of representing the 50 major research universities that comprise the membership of the Association of American Universities. I am also representing the American Council on Education, the National Association of State Universities and Land-Grant Colleges, the Association of Graduate Schools and the Council of Graduate Schools in the United States.

As this Committee knows well, these associations together represent essentially all of the nation's universities and colleges that carry out the research and related education programs supported by the National Science Foundation, the National Institutes of Health and other mission agencies of the Federal Government.

Introduction

The research and development base which this nation has created over many decades remains the strongest and most productive in the world. In spite of our strength, however, there is evidence that the gap between us and our foreign competitors is narrowing, partly because of increased investments in science and technology, and partly because of the erosion in our own research base.

In 1969, our national R&D expenditures were more than twice the combined R&D expenditures of France, Japan, the United Kingdom and West Germany. Just ten years later, in 1979, the combined R&D expenditures of those four countries equalled ours.

Our R&D expenditure as a percentage of our Gross National Product is less than that of most other nations. We have, for example, trailed West Germany for 10 years and the USSR for the last 15 years in this expenditure. If one looks at civilian R&D expenditures as a ratio of GNP, the comparisons are equally revealing: U.S. 1.69, Japan 2.30, West Germany, 2.53.

In spite of recent increases in research and development expenditure, the basic research component of those increases has been modest, and we now face serious problems in the nation's basic research effort. Let me then address the needs of our research universities in four areas:

- graduate education
- young researchers
- research instrumentation
- research facilities

In response to your request, I shall also be glad to say something about the increasing overhead costs associated with doing research, and about the appropriate Federal role in fostering university/industry partnerships. I shall try to cover highlights briefly in my testimony, Mr. Chairman, and hope that you will accept the full written statement for the record.

Graduate Education

Our world seems to grow more complex and more insecure at every turn. Our graduate schools provide the continuing supply of talented individuals with the knowledge, technical skills and perception on which our national security, our economic strength and our cultural vitality depend.

Assuring a continuing infusion into our society of such talent must be a national -- and federal -- priority. Let me give a few examples of the recent fruits of basic research in the medical field which illustrate the direct benefits of research. Medical research has:

- increased the survival rate of childhood cancer victims from 5 percent to 57 percent between 1962 and 1982;
- developed recombinant DNA technology -- with all its potential benefits
- reduced the death rate from coronary heart disease by 30% since 1970 (saving 148,000 lives and an estimated $7.7 billion in 1982 alone); and
- contributed over $40 billion to the GNP each year from non-health related products -- more than the total federal investment in basic research over nearly 50 years.

Federally funded fellowships have been a clear success and an important, even determining, factor in the careers of numerous researchers who have contributed to these and other successes.

But we now face a serious shortage of graduate students in certain fields. For 15 years, federal support for graduate education has been substantially reduced. The number of federally funded graduate fellowships in the physical sciences and engineering has declined from 51,000 in 1968 to about 1500 today. In the face of sharply increasing international competition, critical national needs served by graduate education are going unmet.

The present Administration proposes small, highly targeted increases in university research and development, most notably in the areas perceived to be of closest significance to the national defense. The budgets of three agencies -- NSF, DOD and NIH -- illustrate the limitations of this strategy in providing a solution to our problems.

The Department of Defense proposes to increase its investment in university research programs at a level slightly above inflation, and to award the third class of 40 graduate fellowships designed to attract undergraduates into graduate programs in fields linked to our national security needs. DOD also has undertaken a five-year, $150 million program to upgrade research instrumentation in laboratories that carry out research programs in areas related to our defense needs.

However, the DOD research initiatives, commendable as they are, are at risk at the moment in the House version of the DOD authorization bill for FY-1985.

The FY-1985 budget request for the National Science Foundation is much more encouraging. Augmented in the House Authorization bill by the increases proposed by this Committee, it provides for significant real increases in the Foundation's physical sciences and engineering programs, with somewhat smaller increases proposed for other fields.

Moreover, after almost a decade of neglect, additional steps to strengthen the NSF graduate fellowship programs are proposed. Targeted attention also is being proposed to assist young researchers, who with some encouragement at a crucial point in their careers, may now pursue careers in academic science.

The NSF budget is the centerpiece of the Administration's FY-1985 budget for university research, and I want to express thanks to Dr. Keyworth, Dr. Hess and their associates for these timely initiatives.

I also want to take this opportunity to express to you, Mr. Chairman, and to the members of your Committee, the appreciation of the research university community for your leadership in strengthening the NSF budget and in skillfully negotiating the passage of the authorization bill. These are welcome first steps toward a more comprehensive, government-wide investment strategy to strengthen basic science and graduate education.

In sharp contrast to the DOD R&D budget and the significant proposals in NSF is the sharply restrained request for NIH research activities. The budget request for NIH and ADAMHA once again is below levels needed to sustain even the present research activity. We hope that the members of this Committee and the Congress will again support efforts to protect and sustain university biomedical research and advanced training programs.

There remains an urgent need to attract some of our most able young research workers in science and technology into fields of public priority. The new competitive graduate fellowship program of the Office of Naval Research offers an excellent model for NSF and the other mission agencies. The program offers talented students competitive three-year fellowships with stipends of $13,000, plus full tuition and a $2,000 research award to the host department. The Navy imposes no employment requirements. The motivation of the ONR program is to find and attract a few of our best young minds into advanced education in fields of science and engineering of interest to the Navy.

A stronger, more balanced approach would provide for small graduate fellowship programs in each of the major mission agencies. These would provide for a) merit-based, portable, three-year graduate awards to individuals, and b) an equal number of awards made to students through institutions with high quality graduate departments that carry out basic research programs of interest to each agency. Such a shared effort could provide a total of 1500 to 2000 additional awards annually, for relatively small investments by each agency. The mechanisms are well known, proven and mutually reinforcing. Particular attention needs to be given to the serious shortage of minority students in graduate research programs.

Young Faculty

Closely linked to the needs of graduate students are the increasingly serious challenges that face young faculty in their early careers in research. The attractiveness of an academic career is being diminished by an environment which often provides only outdated equipment and inadequate laboratory space.

We commend the new NSF Presidential Young Investigator Awards program, which is entering its second year with the FY-1985 budget request. The first 200 awards were announced recently. It is encouraging to note that more than 20 of the first class of awards went to women. It is important that this new program proceed uninterrupted during the five-year cycle of the awards.

But the support of young faculty ought not to be the sole responsibility of the National Science Foundation. We urge the Committee to exercise its leadership to encourage the appropriate committees of the House to add small initiatives for this purpose to the research programs of DOE, NASA, USDA, DOD and NIH.

Research Instrumentation

The instrumentation and equipment now being used in many of our research and training laboratories is seriously out of date. This is well documented by survey results, just published by the

NSF, of university research instrumentation systems in three selected fields -- computer and physical sciences and engineering. The report produced the following findings:

- one-fourth of the 1982 research equipment inventory in these fields, which had an aggregate purchase price of $904 million, is obsolete and no longer in research use.
- only 16% of all academic research equipment inventoried is state-of-the-art.
- more than 90% of departmental chairpersons surveyed reported that the lack of equipment inhibited the conduct of critical research.
- 31% of all instrument systems in use in 1982 was more than 10 years old.
- contrary to the expectations of some, university researchers do share equipment at significant levels. Each instrument system in service in 1982 was used by a median of seven researchers. The median number using each piece of computer sciences equipment was 25 researchers.
- 46% of the chairpersons rated the quality of support services (e.g., machine shop, electronics shop, etc.) as "insufficient" (40%) or "non-existent" (6%).

The survey also revealed useful information about current sources of support.

- NSF is the leading federal sponsor of research equipment purchases in the physical and computer sciences, providing about 52% of federal support in these two fields.
- DOD is the primary federal funding agency in engineering, accounting for 45% of the federally financed engineering research equipment.
- nonfederal sources play an important role. In 1982 78% of computer sciences instrument systems, 64% of engineering systems and 52% of physical sciences instrument systems were not federally funded in their entirety. Universities' own funds accounted for at least 70% of the non-federal funds used for equipment in each of these three fields.
- industry funds accounted for 10% of non-federal research equipment purchases.

These new NSF data more than justify sustained investment by NSF and the major mission agencies in university research equipment.

This continued federal investment, while essential, is an insufficient response to the problem. We must search for alternative solutions to make certain that scarce resources are fully utilized. Therefore the AAU, the National Association of State Universities and Land-Grant Colleges and the Council on Governmental Relations have undertaken a study project designed to explore alternative solutions to the equipment problem. The project seeks to identify and evaluate new approaches to acquiring, managing and using equipment, and to inform the university community and others of the results of these evaluations. The project is being supported by six agencies: NSF, DOE, DOD, NIH, NASA and USDA.

A summary of the topics being addressed by the project was presented to this Committee on February 28 by Dr. Robert Rosenzweig, President of the Association of American Universities. I need not discuss it further here, other than to say we are very pleased that these issues have the attention of these agencies and we are looking forward to an interesting and productive result.

Research Facilities

A preliminary NSF survey of 25 universities, just released, conservatively estimates that research universities and colleges require $1.3 billion per year to meet accumulated research facilities needs. In FY-1984 the total Federal investment in R&D plant in universities and colleges is projected to be $40 million, and essentially all of these funds are targeted on special purpose user or national facilities.

I know that this Committee, and other Committees of the House, have begun an effort to understand and address the problems associated with deteriorating research laboratories. A year ago this Committee asked NSF to consider the question, and the House Committee on Armed Services directed the DOD to carry out a comprehensive assessment of the research facilities needs of universities engaged in DOD-sponsored research. We understand that an interagency group is now at work planning that effort. We hope that the Committee will follow that NSF-led effort with interest and encouragement.

There is now no general reinvestment effort by NSF or by any mission agency specifically designed to help with the modernization of the university research laboratories in which agency funded programs are carried out. Just as several agencies have begun to address the research equipment problem, we urge the Committee to ask them also to achieve a shared assessment of the facilities problem by field and to fashion a comprehensive government-wide approach to address it. This is, I must emphasize, the most serious long-range problem facing our research universities.

Throughout these remarks, I have suggested that all of the six major research agencies of government join together to address the four priority areas: graduate education, young faculty, research instrumentation and facilities modernization. Only a shared long-term reinvestment plan and funding strategy will provide the breadth and concentration of resources, consistent with the missions of the agencies, necessary to address the needs.

One such approach has been introduced in the Senate. S. 1537, the "Research Capacity Restoration Act of 1983," has been cosponsored by 20 Senators. I understand that discussions of such a proposal are proceeding in the House. We hope that this Committee will support such a reinvestment plan. I do understand the difficulty of addressing issues of such magnitude in the current budgetary climate, but a solution must be found if our university research capacity is to be preserved.

Experience at Cornell University

I should like to illustrate some of the issues I have addressed with the experience of my own institution. Cornell is among the nation's leading research universities. Sponsored research expenditures in the last fiscal year exceeded $150 million with NSF and NIH being the major sponsors. Our research programs are open and accessible to all who would draw from them. They are fully integrated into our educational programs and we are a major producer of young people educated to serve our national needs. It is vital to the national well being that we provide these young people not only with the opportunity to learn from a group of the nation's leading research workers, but also with the instrumentation and facilities that maximize their value to our society.

I will give a few examples of our needs in these areas.

Universities deal with knowledge. We make it, transmit it, store it and use it. Effective storage and use of knowledge requires effective libraries. The exponential growth of new knowledge makes it ever more difficult to use knowledge well -- or to store it, for that matter. Computers hold the promise of helping to solve the dilemma but the cost is high. Cornell's library of more than 4 million books can be made accessible to users, as can the resources of other research libraries, but the cost will be more than $6 million in "front-end" costs and an added $1 million in operating costs for at least the first five or six years. There is little likelihood that this long-term cost will decrease.

Cornell operates, with NSF funding, a Materials Science

Center. This collaboration between physicists, chemists, and engineers is the largest of fourteen such programs funded by the Foundation. It has operated for 25 years and has contributed significantly to the nation's economy through research and highly trained personnel in the properties and uses of materials so essential in many applications in manufacturing, construction, and fabrication. This fundamental but interdisciplinary area of study intersects every aspect of our daily lives. From the buildings we live in, the cars we drive, the surfaces we drive on, the clothes we wear, to the medical devices we implant -- the list is inexhaustible.

For the past decade, the Cornell Materials Science Center has made capital equipment one of its highest priorities. (The other is start-up support for new, young, faculty.) The Center allocates a minimum of 15% of its budget to capital equipment each year. In some years, the allocation exceeds 20%. These funds are supplemented from time to time by major individual equipment grants. It is anticipated that this policy will be continued into the foreseeable future.

There has been an unprecedented and explosive development in new, sophisticated research equipment in the past 20 or so years, fueled by major advances in electronics and computers. Industry and government have had greater resources than the universities and this has led to a substantial equipment gap. It is nevertheless the Center's estimate that it is not closing the gap in comparison with the equipment resources available in major industrial and government laboratories.

The University, within the last two weeks, has made a very substantial commitment of funds to help the MSC sustain its equipment base and to make it more useful to researchers from Cornell, other universities, and industry. We have proposed to NSF that we will provide $600,000 to assist in the purchase of three major items of equipment that will cost a total of $2 million. NSF is asked to provide the remainder. The individual items, all essential to the study of surface phenomena in industrially important materials, cost $950,000, $700,000, and $350,000 (two electron microscopes, each very different in function, and a device for depositing and analyzing thin films).

It may sound as though this is a "good deal" for the University and in fact it is. The University's problem is how and where to find such major sums of money. The cost of the equipment needed is increasing much more rapidly than inflation. It is not a matter of simply replacing worn out instruments. The new instruments extend our ability to measure and evaluate. They go well beyond instruments they replace in performance as well as in cost.

In the general area of materials science research, despite the commitment I have just described, we can identify a need for more than $4 million of new equipment at Cornell. Without it, our value as a research and teaching resource will inevitably be compromised. We have no source to which to turn for these funds.

A closely related area is long-term research in support of computer chip development. Cornell operates a very successful National Submicron Facility. It is the only center of its kind supported by the NSF. Cornell provided funds for the construction of the facility. NSF provided funds for equipment, and both provide operating funds -- as does the semiconductor industry through a grant from the Semiconductor Research Corporation.

In this vital area, we have identified a need for more than $5 million for new equipment during the next three years.

A third example of new equipment needs is less specific but it is, nonetheless, real and a very important deficiency. As young people replace retiring faculty, the areas and emphasis of programs change. New faculty members need laboratories with new capabilities and new, often different, kinds of equipment. Typically, we must find between $100,000 and $300,000 to equip a laboratory for a new faculty member. We don't always succeed. When you realize that we may appoint 20 or more young scientists a year you can understand why. To the extent that we cannot provide the best possible start for these young faculty members, we limit our technological growth and the value of these faculty members to our society.

The situation with respect to new facilities is even more acute. In areas where we have great scientific competence, we have identified more than $100 million in facilities needs. These areas include biotechnology, plant and molecular biology, microbiology, animal reproductive biology, veterinary medicine, astronomical and atmospheric sciences, electrical engineering, materials sciences, computer simulation and theoretical computations, social and economic sciences, computer sciences, and manufacturing technology. All have been identified as areas of national priority. All are areas in which we have the human potential to make a much greater contribution.

In concluding this portion of my testimony, I should like to quote from Richard DeLauer, Under Secretary of Defense for Research and Engineering, who recently wrote to the President: "Since the mid-70's . . . we have allowed our technological lead to erode and our support for education and research to decline. Our research and teaching institutions already are having serious difficulties producing the quality scientists and engineers needed to regain the technological lead so essential to our future security and economic well being."

Indirect Costs

The past two years have seen increased attention paid to university indirect cost rates for federally sponsored research. In FY '83 and '84, the Department of Health and Human

Services proposed cutting reimbursement of indirect cost by 10%. Universities objected to this proposal as arbitrary and destructive of the institutional capacity to conduct federally-sponsored research. This proposal is not part of the Administration's FY '85 budget; the President's Science Advisor has proposed a study of the issue in the context of the universities' continued capacity to undertake federally funded research.

As you know, cost-based reimbursement replaced a fixed rate in 1965. At that time, the federal government decided that institutions should be reimbursed for the actual cost of the research (after factoring in mandatory cost sharing) instead of a flat rate.

In the period following the removal of this cap, indirect costs have risen to reflect the actual costs of the research. These include inflation (which disproportionately affects indirect costs), increasing federal regulation, and the federally instituted requirements for more detailed cost accounting. To sum up the major reasons for the increase in indirect costs as a percentage of total costs:

1. Indirect costs were artificially capped in the years before 1966.

2. Inflation has resulted in a greater rise in non-personnel costs than in salary costs.

3. The cost of compliance with government mandated health, safety, social and administrative standards has increased.

4. The nature of research has changed: it is more complex and requires greater institutional support; research teams and projects are larger; more equipment and other resources are shared and the costs are charged to indirect cost categories instead of direct cost categories.

5. Legitimate costs of research, once covered by university resources, must now be recovered through indirect cost reimbursement.

6. In a period of increasing financial stringency, universities have practiced better management and have improved identification of costs.

The most recent revision of OMB Circular A-21 (which sets forth the basis upon which indirect costs are calculated) included allowance for interest paid to external sources for construction and renovation of facilities. While this change was welcome, it is not likely that it will contribute significantly to the renovation or construction of university research facilities in the foreseeable future. There are two reasons for this:

1. The advantages in indirect cost recovery accrue only after the institution has obtained funds for facilities from an "external source;" such funds are not available on a significant scale.
2. Concern over increases in indirect cost rates is such that universities are reticent to take any actions that will increase them.

It should not be overlooked that indirect cost rates are always approved retrospectively, in discussions which involve continuous and detailed federal audit of all costs already incurred.

The Role of Government in Fostering University-Industry Relationships

Industrial support of university research is one of the most significant developments of recent years, but the significance can be easily overstated. The magnitude of industrial support is now about 3% of total university research expenditures; few experts see it ever rising to more than 8-10%. Further, industrial support is not a new phenomenon. It has existed for decades in a great many of our leading institutions.

Still, the magnitude of recent developments constitutes significant change. In every year since 1970, industry funding of university-based research, in constant dollars, has increased. Total funding doubled between 1970 and 1983; it increased by 11% in 1980-81 alone. According to Science Indicators 1982, half of the support is in engineering.

A variety of funding mechanisms, institutional arrangements and cooperative agreements are in place and more are being developed. Often the award of an equipment grant from the NSF, DOD or another agency is proving to be a catalyst in the formation of these new arrangements. So an important side benefit of federal investment in research equipment is the stimulation of new research relationships between industry and university researchers who are appropriately equipped to address research questions of interest to industry.

One of the most significant incentives developed by the Federal government to stimulate industry support for university research activites is the provision of the Economic Recovery Tax Act of 1981 which encourages the donation of research equipment to universities. This appears to be having a very significant impact, in certain corporations. It ought to be strengthened to provide for the donation of instructional equipment, for equipment previously used by the donor for less than three years, and to remove present ambiguities over the donation of computer software.

This tax incentive clearly is valuable where large corporations are concerned. In the case of small, innovative companies, however, different kinds of stimuli are needed to assist in the development of sophisticated new instrumentation. University researchers have special requirements for this kind of instrumentation, and can play an important interactive role in assisting a small company to meet the difficult challenges involved. We need to find new ways to assist in procuring such instrumentation and to assist the industry-university interaction to take place.

The Economic Recovery Tax Act also provides an incentive for the support of university-based research. The effectiveness of this particular provision is somewhat more difficult to assess, but in time this too may prove helpful.

Mr. Chairman, these hearings have raised questions of major importance. Our present responses to them will influence our national life well into the next century. We wish to commend and thank you and the Committee for raising these fundamental issues.

I will be pleased to answer any questions you may have.

- APPENDIX -

U. S. Research and Development: The Changing Scene

National Expenditures for Research and Development

Total national R&D expenditures have grown steadily in recent years, although the basic research component of that growth has been modest. According to a recent report by the Congressional Budget Office, Federal Support for R&D and Innovation, R&D funding has increased 41 percent since 1980 (an increase of 10 percent in real terms). In FY-1984, according to figures prepared by the American Association for the Advancement of Science (AAAS), total national funds for R&D will be $97.9 billion, an increase in current dollars of more than 11 percent (6.2 percent in constant dollars) over 1983.

Inflation, however, has taken a severe toll on the nation's total investment efforts. A sixfold increase achieved during the period 1960 to 1983, adjusted for inflation, is only doubling. (Universities and colleges more than tripled their own investment in R&D over this period of nearly a quarter century.)

The federal role in R&D is changing, both in the magnitude of the federal investment and the character of the work being supported. Defense-related R&D, including Department of Energy (DOE) defense spending, has grown from 48 percent of the total R&D budget in 1980 to 70 percent in 1984 -- a real increase of 53 percent. Most defense R&D funding is for development, not fundamental research. According to the Congressional Budget Office report cited earlier, DOD spends by far the smallest proportion on basic and applied research of all the major agencies that fund significant amounts of R&D. If defense-related development funding is omitted, the real funding for R&D in FY-1984 is only 78 percent of the 1980 level.

While the Administration has increased defense-related R&D, it has cut civilian applied R&D and at the same time provided a compensatory government-wide increase for basic research of 10 percent over four years. This de-emphasizes applied research, often seen as the bridge to technological innovation and industrial development.

The R&D role of industry is also changing. In 1980, for the first time in 20 years, industry invested more than the federal government in R&D. In 1984 industry accounted for an estimated $50 billion in R&D expenditures, slightly more than half the national total. Thus industry has become the largest source of R&D support in the U.S. Most of industry's investment, as in the case of federal defense R&D, is in development, not fundamental research.

Universities also fund research from their own or donated sources. These funds typically are spent to augment particular research programs or to provide seed funds for young investigators. In 1984 universities and colleges spent an estimated $1.7 billion of their funds for research, a sum equal to just 3 percent of the total industrial effort. Science Indicators, however, projects a decline in R&D support provided by the academic sector. The same report projects expansion in industry R&D investment (which grew between 1980 and 1983 at an annual rate of 5.4 percent in constant dollars), and in federal investment (which grew at a rate of 3.1 percent).

As a performer of R&D, industry accounted for 75 percent, or $73 billion, of the total national R&D effort in 1984. Government intramural laboratories accounted for $11 billion. It is predicted that universities and colleges this year will perform a total of $8.4 billion of the total $97.9 billion national R&D effort.

To illustrate the effect of inflation, academic R&D grew at an annual average rate of 12 percent during the 1960's. That slowed to 2.6 percent in the 1970's. In constant dollars, expenditures for academic R&D are estimated by Science Indicators - 1982 to have declined slightly between 1980 and 1983.

National Expenditures for Basic Research

Most academic R&D historically has been basic research. Science Indicators - 1982 estimates that 25 percent of all research and about 50 percent of the nation's basic research is carried out in university laboratories. The primary national sources of support for university basic research are NSF, NIH and the other mission agencies of the government. Together they account for 70 percent of the total national support for basic research, and they also provide about 70 percent of the total investment in academic basic research.

Measured in constant dollars for the period 1960 to 1983, the total national investment in basic research grew almost threefold from $1.7 billion to $4.8 billion. The federal share of that investment grew from $1 billion to $3.2 billion. Industry expenditures increased by a factor of 1.8, from $497 million to $914 million. (Industry's real-dollar expenditures for applied research almost tripled and investment in development quadrupled.) Universities and colleges increased their own constant dollar investments in basic research fourfold, from $103 million to $440 million.

Trends in Academic Science and Engineering

One hundred years ago, fewer than 2 percent of our citizens between the ages of 18 and 21 enrolled in higher education. Now 30 percent of the individuals of college age are enrolled in our 3000 or so universities and colleges. One-third of our four-year institutions have been established since 1960; 1447 of our four-year colleges offer science and engineering degrees.

The number of institutions offering advanced science and engineering degrees has doubled since 1960. The number of advanced degrees in science and engineering awarded annually has tripled since 1960. At the same time, our universities have retained a great commitment to and investment in undergraduate education. In 1980 doctoral institutions awarded 54 percent of all baccalaureate degrees conferred in the country.

The total enrollment of science and engineering students increased dramatically during the 1960's, and now it is roughly stabilized at slightly below historically high levels. Important shifts, however, have occurred within and among specific fields. These changes will affect our capacity to meet the nation's future scientific and technological needs.

Changing enrollment patterns in key fields, such as computer sciences and engineering, are creating serious problems for universities in recruiting young faculty. Between 1970 and 1981 the number of bachelor degrees in the computer sciences increased tenfold (from 1500 to 15,000). Undergraduate engineering enrollments are at a high point, with students drawn by an attractive job market.

An important problem is to attract a sufficient number of U.S. citizens into our graduate programs of science and engineering, at a time when unprecedented numbers of foreign students are enrolled in our research institutions. During the period 1974 to 1981, foreign students accounted for almost 50 percent of the net growth in science and engineering graduate student enrollment.

In 1981 foreign students accounted for more than 20 percent of all full-time students enrolled in graduate science and engineering programs. They accounted for 43 percent of total full-time graduate students in engineering, 36 percent in mathematical and computer science, and 27 percent in the physical sciences.

Foreign researchers are accounting for an increasing proportion of postdoctoral researchers as well. In 1981 the proportion of postdoctoral trainees at doctoral granting institutions of foreign origin was 46 percent in physics and 68 percent in engineering. Some of these students remain in the U.S., but most return home, leaving us with a continuing lack of highly qualified and trained U.S. citizens to be faculty and researchers in crucial fields of science and engineering.

This, it must be emphasized, is not a problem of too many foreign students attending our institutions. Our world-wide role is a genuine strength and national treasure. This is, instead, the problem of our inability to attract a sufficient number of highly qualified and motivated American citizens.

The importance to our universities and our research enterprise of addressing this problem is underscored by the fact that in 1981, almost 30 percent of all scientists and 5 percent of all engineers in the U.S. were employed by educational institutions, primarily by our universities and our colleges. More than one-half of our doctoral level scientists and engineers are employed in our universities and colleges.

In the fall of 1981 an estimated 9 percent of all full-time engineering faculty positions were vacant. This shortage occurred despite a 12 percent increase in academic R&D expenditures (in current dollars) in engineering. Moreover, total undergraduate enrollments reached new heights, growing at 9 percent per year. This places great burdens on teaching faculty, who are increasingly hampered by outmoded research instruments and instructional equipment, and by outmoded research and instructional laboratories and facilities.

Mr. MacKay. Thank you very much, Dr. Rhodes.

Mr. Mineta, do you have any questions?

Mr. Mineta. Thank you very much, Mr. Chairman.

Doctor, welcome to the panel. Your perseverence in getting here through Hagerstown is very much appreciated by us.

Let me just ask about the whole issue of a point that was made by Dr. Young, the chancellor from UCLA, about tying the support for research infrastructure to a specific project so that it can get the necessary amounts for the construction of facilities, so that we are not just funding the research effort itself but whatever might have to go along with providing that.

Now to what extent would that be, maybe, a transfer from, let's say, a State university or a private university to the Federal level, and given the fact that we have a shrinking pie rather than an expanding pie, how do we then try to determine whether or not we ought to be dealing with the infrastructure or the building part of it as compared to the project itself? Should that be done by peer panels? Should that be done through NSF's—what's it called—cross-disciplinary research and engineering program type panels?

Dr. Rhodes. Mr. Chairman, I did not have the benefit of hearing Dr. Young's testimony, and so let me reply not knowing exactly what was said, but the question you raise is a very important one. The need you have identified is a fundamental one and, as I mentioned a moment ago, I think it is the most serious long-term need the universities face if we are continuing to serve the Nation adequately in our research undertakings.

I think the Federal Government has to play a role in this. The development of state-of-the-art labs, in some of the high technology and the most advanced science areas, is one that I believe State governments and private funding are going to be unable to meet, if we take the overall needs of the Nation.

As to how it is done, I believe the peer review system is one that has served us very well, and I and others I know worry that the politicization of the award of facilities funding could in fact weaken our long-term effort. We think the best judges of competing needs—and they will always be competing—in the field of scientific and engineering facilities are those actually working in the field, and that's why NSF and similar peer panels seem to us to serve the Nation's interests well.

Mr. **Mineta**. But how do we get away from the realities of the politicization of the process?

Dr. **Rhodes**. My hope, Mr. Chairman, is that——

Mr. **Mineta**. We experience that right here in this committee, not on any partisan basis but probably by the kind of an area that you represent. I happen to represent that silicon valley area, and I am pleased to hear that Semiconductor Research—SRC—has money at your institution dealing with semiconductors, but we are going through a tremendous program right now or a decision on this thing called the Centers for Advanced Materials out at Berkeley.

Dr. **Rhodes**. Yes.

Mr. **Mineta**. Other facilities or universities are saying, "Oh, hold it, we can do it just as well," and yet we have all of the giants in the semiconductor industry in our area saying, "We ought to do it at Berkeley." Berkeley is outside my area, but still the political aspects of it get into it. Even though there has been a peer review, there are still others saying, "No, it ought not to go there. It ought to go somewhere else, or the money ought to be divvied among other universities." So even with peer review it doesn't really eliminate it because we still have the authorizing committees in the Congress and we still have the appropriating committees that determine when in fact, where in fact that money will be going.

Dr. **Rhodes**. I understand that, and I don't think in reality we shall ever escape it. I'm not sure that we should hope to, but I do believe that the difference between the best and the second best is enormous in the field of research. It's not just a gap; it's a chasm between the two, and I hope that we can stay with procedures which simply give us the best shot at recognizing the best. We shall not always be right. There will still be some political considerations, but I think the way to do that is to identify needs, to make block appropriations, and then to let peer panel groups make the awards. The worst solution, I believe, would be a buckshot type of approach where we scattered a limited level of funding between a large number of institutions. That will buy us nothing, not even harmony in the long term. It will certainly not buy us progress in scientific terms.

Mr. **Mineta**. I chair the Aviation Subcommittee for the Public Works and Transportation Committee, and in the bills that we produce from our subcommittee I want to make sure that we don't have place-naming, that we don't place-name projects in our bills. I constantly have to fight the Appropriations Committee to have them not place-name, so that we could let the objective merits of the applications coming in determine where the moneys will go.

But, by the same token, if the moneys are going to be or the distribution of those funds is going to be done on a political basis, then I have no alternative but to have to seek those funds for my district, or any of the members here have to do that on their own. It's such a difficult thing to try and keep a "clean bill," free of "no less than" or "up to," shall be used for this project or that project in our aviation area. But it's a constant fight, because you're always having to say no to your own colleagues who come to you and say, "Hey, Norm, would you put $20 million in for my airport, because we really need it, we need it for economic development." I say, "Absolutely not," and as long as we can keep it that way it seems to me we are OK. Then we can allow objective merits to determine whether or not airport A or B or C gets funded, but once you get Congressman X, Y, or Z fighting for their own projects—again, in the field of research I find that happening here, and I am a new member to this committee—so I am going to fight just as hard for the projects that are going to be benefitting the State of California or an interest of mine. I am just wondering how you ever get away from it, if it is possible, how you do.

Dr. RHODES. I understand the tension, and I wish I had a simple solution to what is really a very complex problem. I can only say that universities face the same kind of problem, and their presidents share in it. But I think what we've got to do is just to insist that there will be no funding to distribute, no wealth to reallocate, unless we can generate long-term wealth for the Nation, and that's everybody's priority. It is every constituent's priority, and our best hope is not a short-term solution that gives a short-term benefit to one community. It is a long-term solution that increases our economic strength, that improves our industrial productivity and generates national wealth for all. I hope we can maintain that balance.

Mr. MACKAY. Mr. McCandless.

Mr. MCCANDLESS. Thank you, Mr. Chairman.

Dr. Rhodes, some of your figures that you gave us in your presentation about equipment I found very interesting. I have that information on page 6 of your submittal.

Dr. RHODES. Yes.

Mr. MCCANDLESS. I would like to kind of build a foundation, if I may, in the time we have. You spoke of Cornell as being one of the 50 largest research centers. What percentage of your research money would come from the Federal Government, the private, and then the other sectors? Can you tell us just roughly what that might represent?

Dr. RHODES. Yes. Our total sponsored research is just over $150 million, and my recollection is that $116 million of that comes from the Federal Government, $116 million. It's rather more than two-thirds.

Mr. MCCANDLESS. Private, do you do much in the way of private?

Dr. RHODES. About 9 percent of our total comes from industry. That's above the national level. The national level is around 3 percent.

Mr. MCCANDLESS. All right. Then you referred to academic research equipment, as the fact that only 16 percent of that represented the state-of-the-art and that 90 percent of the people surveyed said they lacked equipment which inhibited the critical research necessary.

Then the other point that I picked out was that 46 percent of the people in this group said that their support services were insufficient to maintain what it was they had in the way of equipment.

If $116 out of $150 million in your budget comes from the Federal Government, then wouldn't there be a portion of that that would go toward the replacing or the updating or the required purchasing of equipment to carry out what it is that you have been given in the way of an assignment in the research field?

Dr. **Rhodes**. Yes. Let me reply to that, Mr. Chairman, that our Federal funding comes to us in two kinds of packages. Much the biggest part comes to us in response to particular requests for particular research programs. Those individual programs are funded, and they may or may not contain equipment. Often equipment will be requested but that request will not be met, even though the rest of the funding is provided, so in a few cases they do provide funding but in most not on the scale that is going to serve the overall larger needs.

You can't, for example, get a major new piece of instrumentation costing, let's say, $1.5 million, on a small research project of $300,000. The National Science Foundation and other agencies won't generally accept that need, and it's the larger scale instrumentation where we face major problems, instrumentation shared by dozens of scientists and engineers.

That's package No. 1, funding applied to particular scientific and engineering problems. The second way we receive funding from the Federal Government is in a block grant for the Materials Science Center, for example, that I talked about very briefly. From that we are free to allocate funding ourselves, and on those grants we do in fact set aside 15 to 20 percent a year for equipment replacement, but it doesn't begin to keep up with our needs. The fields in which we are engaged are changing so rapidly that equipment has a more and more limited useful life.

Mr. **McCandless**. Within the budget of the university itself you would have the three categories—facilities, personnel, equipment maintenance—and the others.

Dr. **Rhodes**. Yes.

Mr. **McCandless**. You touched on this briefly but, since you are a large research center, is there a line item in your budget that says replacement of equipment each year when it comes to the approval process?

Dr. **Rhodes**. There is a small line item in our budget. It's very small. From our total budget it's less than $1 million but we do at year end with funds—scrambling to find them where we can—meet equipment needs which are the most pressing. We do go to industry for specific gifts. We had a major one from a major corporation just last week, and we do share costs with the Federal Government in buying major pieces of equipment, but we do not have a large enough endowment to put aside a significant portion for equipment replacement, and we cannot add it onto student tuition which next year will be over $9,000 a year.

Mr. **McCandless**. Yes. I have had some experience in that field of tuition.

Would these figures reflect, say, the top 50 major research universities? I understand that this is a compilation of an entire grouping.

Dr. **Rhodes**. Yes. This particular one, the National Science Foundation, I'm not sure of the sample on which it was based but I believe my colleague, Mr. Crowley, may be able to help me.

Mr. **Crowley**. I don't have a detailed answer to that. We would be happy to supply it for the record.

[The information follows:]

The National Science Foundation reported on a survey of university research instrumentation systems in three selected fields—computer and physical sciences and engineering. The survey covered 43 universities selected from the 157 largest academic research and development performers. More than 90 percent of the department chairpersons and investigators in these fields at these universities responded to the survey.

SCIENCE RESOURCES STUDIES HIGHLIGHTS
NATIONAL SCIENCE FOUNDATION WASHINGTON, D.C. 20550 April 18, 1984 NSF 84-312

One-fourth of Academic Research Equipment Classified Obsolete

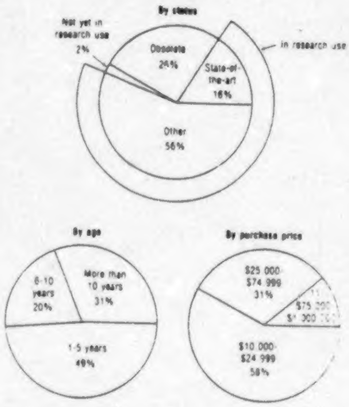
This report presents information from the National Science Foundation's (NSF's) National Surveys of Academic Research Instruments and Instrumentation Needs. Data were collected from a stratified probability sample of 43 universities selected from the 157 largest academic research and development (R&D) performers. More than 90 percent of both department chairpersons and investigators responded to the survey. This survey was designed to yield nationally representative information on the amount, condition, and cost of existing scientific research instrument systems in calendar year 1982 in three selected fields—the **computer** *and* **physical sciences** *and* **engineering.** *Data are currently being collected for the agricultural, biological, environmental, and medical sciences. The NSF study was limited to research instrument systems costing from $10,000 to $1,000,000. Except where otherwise noted, all data represent national estimates.*

Highlights

- University researchers classified about one-fourth of the 22,300 items in their 1982 research equipment inventories as obsolete and no longer in research use (chart 1). Of the three fields studied, the situation was more severe in the physical sciences and engineering for which 24 percent of equipment items were obsolete, as compared to computer sciences (17 percent).
- Of all academic research equipment listed in the 1982 inventories, only 16 percent was characterized as "state-of-the-art." This proportion did not differ significantly among the three fields surveyed (chart 2).
- When asked to classify the adequacy of research instrumentation available for both tenured and untenured faculty in their units, about one-half of departmental chairpersons reported existing equipment to be "insufficient."
- More than 90 percent of the departmental chairpersons in each of the three surveyed fields reported that the lack of equipment inhibited the conduct of critical research.
- One-half of all academic research instrument systems in use in 1982 was purchased within the previous 5 years, but 31 percent was more than 10 years old. Computer sciences stands out from the other two fields. Only 12 percent of the computer equipment was purchased prior to 1971; 78 percent was purchased since 1978.
- The aggregate purchase price of research instrument systems in the 1982 university inventories in these three fields was estimated at $904 million.
- Two-thirds of all academic research instrument systems in use during 1982 were acquired partly or entirely with Federal funds. The proportion of instrument systems for which

Chart 1. Academic research equipment in computer and physical sciences and engineering: 1982

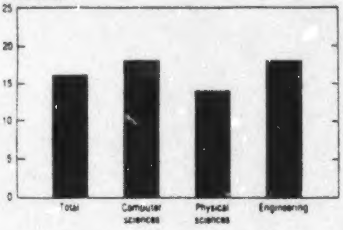
(Total number of units: 22,300)



SOURCE: National Science Foundation

Prepared in the Universities and Nonprofit Institutions Studies Group, Division of Science Resources Studies

Chart 2. State-of-the-art proportion of academic research instrument systems by field: 1982



SOURCE National Science Foundation

Federal funding accounted for at least one-half of the purchase price declined from 62 percent in 1978 to 31 percent in 1982.

- Department chairpersons estimated that expenditures for research equipment would rise 20 percent between 1982 and 1983 with the greatest relative increase in the computer sciences 22 percent. Spending for engineering equipment was expected to rise 17 percent, and for equipment in the physical sciences 12 percent.
- Each instrument system in use in 1982 was used by a median of seven researchers. The median number using each piece of computer sciences equipment 25 researchers, was nearly four times the number using scientific apparatus in the physical sciences or engineering.

Methodology

Inventories for all existing research equipment were obtained from institutions' central recordkeeping systems and were sent to departmental chairpersons for verification.[2] Subsequently, two types of questionnaires were provided to the departments. Chairpersons provided generalized information on equipment needs, trends, and future estimates within their own units while researchers provided data on specific research systems in the three fields studied.

Inventory Characteristics

PURCHASE PRICE

The aggregate value based on initial purchase price, of the research instrument systems at universities in 1982 in the three fields surveyed was $904 million.[3] Nearly six-tenths of the science/engineering (S/E) instrument systems were purchased at prices ranging from $10,000 to $24,999; prices for another three-tenths ranged between $25,000 and $74,999; and about one-tenth were priced between $75,000 and $1,000,000. Based on research investigators' estimates purchase costs of systems in use in 1982 were $690 million. The cost of replacing these systems was $984 million, or 43 percent greater than the original aggregate value of the systems.

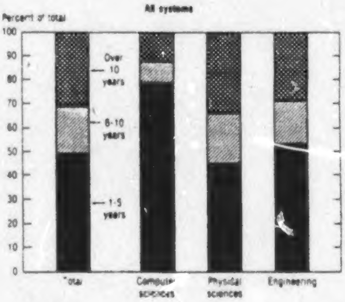
About 13 percent to 14 percent of systems in the computer and physical sciences cost between $75,000 and $1,000,000 and 8 percent of the systems in engineering fell in this price range. For all three fields combined, 24 percent of the more expensive research instrument systems were classified as "state-of-the-art." Thirty percent in engineering, 22 percent in the physical sciences, and 18 percent in the computer sciences were so classified.

AGE

One-half of the aggregate value of instrument systems in the 1982 national inventory consisted of items purchased between 1978 and 1982.[4] In the computer sciences, however, more than three-quarters of the aggregate value of systems in university inventories was accounted for by items purchased after 1977. This reflects the rapid rate of technological developments in that field. Nearly all "state-of-the-art" equipment (98 percent) in the computer sciences had been acquired since 1978, as compared to 80 percent in the physical sciences and engineering. Also, 84 percent of the equipment classified as "state-of-the-art" was described as being in excellent condition, compared to 42 percent of all other instrument systems in research use.

The median age of academic research instrument systems in the 1982 national inventory in the three S/E areas surveyed was 6 years. In the physical sciences the median age was 6 years; in engineering, 5 years; and in the computer sciences, 3 years. For "state-of-the-art" instrument systems, median age was only 3 years in both engineering and the physical sciences but in the computer sciences, only 1 year (chart 3).

Chart 3. Academic research instrument systems in use in 1982 by age and field



SOURCE National Science Foundation

Funding Patterns

The National Science Foundation (NSF) was the leading Federal sponsor of research equipment purchases in the physical and computer sciences, providing about 32 percent of Federal support in each of these two fields. In engineering the primary Federal funding agency was the Department of Defense, which accounted for 45 percent of the federally financed engineering research equipment. The extent to which non-Federal sources contributed towards the acquisition of academic research equipment is reflected in the number of instrument systems in 1982 that were not 100 percent federally funded. In the computer sciences 78 percent of the systems were not entirely funded by Federal agencies; in engineering, 64 percent; and in the physical sciences, 52 percent (table 1). In most cases, researchers found additional funds for equipment within their own institutions. Universities' own funds accounted for at least 70 percent of non-Federal funds used for equipment in each of the three fields surveyed.

Research instrument systems in private institutions tended to have more Federal support than systems in public schools. Nearly 80 percent of the systems in private schools received some Federal support; 54 percent were entirely federally funded. In contrast, Federal financing played a role in the acquisition of 54 percent of research equipment in public institutions; 35 percent of the systems were purchased entirely with Federal funds. This pattern appears to have continued into 1983. Department chairpersons in public institutions estimated that the proportion of their federally financed expenditures for research equipment would decline between 1982 and 1983, while chairpersons in private institutions anticipated an increase in Federal instrumentation support in 1983.

Industry funds accounted for 10 percent of non-Federal research equipment purchases. In private institutions industry funds accounted for 20 percent of the non-Federal total as compared to 6 percent in public universities. Industry support may become more balanced in the near future. Chairpersons indicated that industry's help with equipment purchases was expected to nearly double in public institutions between 1982 and 1983, while it would decline slightly in private institutions.

Table 1. Academic research instrument systems in use in 1982 by field, institutional control, and source of funds

Principal field of research use and institutional control	Percent of systems receiving			
	Total	100-percent Federal funding	Partial Federal funding	No Federal funding
Total	100	42	22	36
By field				
Physical sciences	100	48	25	27
Engineering	100	36	17	47
Computer sciences	100	22	30	48
By control				
Public	100	35	21	44
Private	100	54	24	22

SOURCE: National Science Foundation

Utilization

One-third of the in-use instrument systems were dedicated for specific experiments, thus limiting the accessibility of these systems to users. Systems dedicated to a specific experiment had a smaller median number of users (4) than that for all systems (7). More expensive instrumentation systems had the greatest number of users in all three S/E areas. In systems with a purchase price of $75,000 to $1,000,000, the median number of users was 13. This pattern was generally representative in both the physical sciences and engineering. In the computer sciences, however, the median number of users of systems costing between $75,000 and $1,000,000 was 63, much higher than the median of 25 users reported for systems in all cost ranges. About three-fourths of the users in all S/E fields were faculty or graduate students from the department staff. As the purchase price and the number of users increased, the portion of users from other departments and other universities rose from one-fourth to one-third of the total (table 2).

The median number of users of "state-of-the-art" versus other systems in research use did not differ significantly, except in the computer sciences, where the median number using "state-of-the-art" systems, 6, was significantly less than the median of other in-use systems, 46.

Table 2. Mean and median number of users of academic research instrument systems in use in 1982 by field and purchase price range

Principal field of research use	Total		$10,000-24,999		$25,000-74,999		$75,000-1,000,000	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Total users	17.9	7	14.5	6	18.4	7	30.1	13
Physical sciences	15.2	7	10.8	6	16.0	7	28.4	13
Engineering	14.4	6	13.4	6	13.6	6	22.6	11
Computer sciences	64.3	25	61.8	46	55.5	18	96.0	63

SOURCE: National Science Foundation

Equipment Adequacy

Department chairpersons were asked to evaluate the adequacy of research instrumentation available to researchers in their units. "In terms of its capability to enable investigators to pursue their major research interests . . ." chairmen rated the adequacy of the research equipment for tenured faculty and equivalent principal investigators in their departments as follows: 8 percent—"excellent," 46 percent—"adequate," and 46 percent—"insufficient." The rate for untenured faculty was roughly the same. Although the computer sciences tended to have both newer equipment and a greater portion of "state-of-the-art" instrument systems, chairpersons in this field rated the adequacy of systems lower than in the other two S/E areas. As previously noted, nine-tenths of the chairpersons in this study reported "important subject areas" of research that could not be performed in their units because of the lack of needed research instrumentation.

When asked to assess the quality of support services (e.g., machine shop, electronics shop, etc.), 6 percent of the chairpersons rated services as "excellent," 47 percent as "adequate," 40 percent as "insufficient," and 8 percent as "non-existent." In the computer sciences, 40 percent of the chairpersons reported that services available to their organizations were "excellent" or "adequate."

A more detailed analytical report covering this survey's results will be published in 1984. The second phase of this study is currently underway for which final results will be available in early 1985.

Footnotes

[1] Includes nondepartmental research facilities.

[2] Included are systems used for research in 1982, research systems under construction, and research systems no longer in active use. Not included are instruments intended primarily for purposes other than research (instructional, machine shop, etc.). Preliminary estimates, not adjusted for nonresponse, encompass approximately 90 percent of the above universe.

[3] This portion may actually be slightly higher; totals for 1982 are incomplete. Some late-1982 acquisitions had not been entered on university inventory systems by early 1983 when inventory listings were obtained.

[4] Does not include industrial donations.

[5] Dedicated instrument systems as distinguished from general purpose research instruments may or may not involve modifications such as special calibration, programming or other adjustments which render the instrument unsuitable for general purpose use.

[6] Since a few very large and expensive systems in each field had a disproportionately high number of users, the median number of users for all instrument systems was significantly lower than the mean, about 10.

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Mr. McCANDLESS. I guess what I am trying to establish is, if this is a cross section of the total university system——

Dr. RHODES. It is. I think it's reasonably representative.

Mr. McCANDLESS. Then if we take the top 50 universities, how might they fit percentagewise in these categories? Would we say that only 16 percent of their equipment is state of the art, or would those top 50 universities have 35 percent state of the art?

Dr. RHODES. My guess is that the figures will not be very different from those. I am sure they will vary a little, but I think these are representative figures, and we can give you the information, the sample size on which it is based.

Mr. McCANDLESS. Getting back to the support services and Cornell's budget, it would appear—and maybe my assumptions are incorrect—it would appear that in the case of an institution such as yours where you have the high level of research, that there would be as a part of the budget a requirement to be able to service that equipment, which would not be characteristic of your comment about the support services as being insufficient or nonexistent. It's kind of like preventive maintenance if you had a fleet of automobiles or trucks, to maintain the equipment properly. Is that an improper assumption, that you do not have facilities to maintain the equipment?

Dr. RHODES. No; it's a proper assumption. In an ideal world that would be the case. It is a very difficult thing to put together a continuing service arrangement—by which I mean machine shops and electronic shops and so on—from piecemeal Federal grants. We do the best we can, but I think most people would agree we do a very inadequate job there. They are not nonexistent but they are certainly inadequate in most universities. The problem is that they are funded from piecemeal funding of particular projects, as well as some university support.

Mr. McCANDLESS. Thank you very much, Doctor.

Dr. RHODES. Thank you.

Mr. McCANDLESS. Thank you, Mr. Chairman.

Mr. MACKAY. Dr. Rhodes, it seems to me that we are reaching a point where we want more research than we are willing to pay for, and it seems to me that we are reaching a point where there may be finite limits on the amount, at least in the area of civilian research, that we can reach a consensus to pay for. Now when we reach that amount, it seems to me someone is going to have to do some painful thinking as to whether we should limit the scope of what we are doing or whether we should try to stretch our instrumentation dollars more or operate in inadequate facilities. We seem to be backing into that kind of policy decision.

One area that, it seems to me, is going to be more of a focal point is addressed in the appendix to your statement, and it has to do with the number of foreign students that we are now serving. You make the comment that that doesn't mean we are serving too many foreign students; it means we are not attracting enough American students.

Well, I could draw a different conclusion from that. Since we don't have enough money to pay for everything, why don't we quit paying for all of those beyond the number of American students? Would we not then have a great deal more instrumentation money? In other words, have you not made a kind of a Federal policy and are we not, without thinking about it, sort of saying, "Well, you can go ahead if you want to but we are not going to pay for it."

Dr. Rhodes. Yes. Well, there are probably three things to say in response to that. Some foreign students stay—I am one, of many years ago—and contribute in ways more or less useful to our own national scientific effort. The second thing to say about it is that these people, when they return to their homes, I believe contribute to the scientific effort on a global scale. The value of trained agriculturalists going back to India, for example, trained in our universities, has been the major factor in solving India's food problem. It has been the turnaround, the swing factor over the last 10 years, in the improvement that we have seen. That has to be a global benefit in which we as a nation, can take some pride.

And the third thing to say is that I don't regard people at the graduate and postdoctoral level—which is where our big foreign student concentration is—as a drag on the system. In fact, if they were not present, much of the research which we create would not be undertaken simply because of the inability of universities to put together the research teams that conduct it, so there are real benefits, and I don't believe the Federal contribution to those people is a major part of the total Federal funding.

Mr. Mineta. Mr. Chairman, may I just make an observation in support of what Dr. Rhodes has said?

Mr. MacKay. Yes, Mr. Mineta.

Mr. Mineta. This year, of the five Nobel Laureates in the United States, three were foreign-born—Canada, France, and India.

Dr. Rhodes. Those are important figures, Mr. Chairman. If one looks at the longer term picture, since World War II, I believe the pattern that you have just described holds up also. My recollection is that it is around 60 percent who are foreign-born. That's the importance of the ones who stay here, come here.

Mr. MacKay. I don't disagree with what you're saying. I am simply saying that, taken in the aggregate, it appears that an inadequate job has been done of selling this idea or else an inadequate job has been done of selling at the Federal level the idea that we need to put greater support into graduate education and research. It would appear that the university community, which is the primary point at which basic research is done in this country, needs to focus its effort more on the idea of selling the benefits of this, but you don't need lectures from me.

Dr. Rhodes. I accept that responsibility.

Mr. MacKay. If we talked in terms of a stabilized Federal role, at which point would that—you cited four points, the young researcher, the facilities problem, the instrument problem—taking into account that higher education has traditionally been more of a State responsibility, what would be the best Federal support role? If we just simply said you could rely on the Federal Government from now on for a certain level of support, where would we best do that?

Dr. Rhodes. Yes. I would pick two out of the four. It's a little like deciding whether you want to do without a right hand or a left hand, but if I am pressed, and you are pressing me, I would say that two are of prime importance.

One is the training of young graduate students, young research workers who will be the future leaders of NASA and Agriculture and NIH and every other Federal priority and activity we have, support for graduate students.

The second one is facilities, because the level that we are talking about in the support of facilities is one that the States and private industry are not going to be able to provide, and it's in our national interest to have state-of-the-art labs, a few of them, in every one of the major competitive areas. Our overseas competitors do it. You mentioned, Mr. Chairman, a moment ago that we may well be reaching the limits of Federal support for research and development. I am reminded that our most powerful economic competitors have a much higher ratio of civilian research and development to gross national product than we have. I quoted the figures of West Germany being more than 2.5, Japan being 2.3, and our own ratio being 1.69. I believe we can learn something from their economic strength about the value of that level of investment.

Mr. MacKay. I fully agree with that, and feel that that also is an issue that must be developed in a way that the common person understands that he or she has an interest in that, and the future of this country to a great extent depends on those numbers you just cited.

Dr. Rhodes. Yes.

Mr. MacKay. But it is not seen as something that is a "Joe Lunchbucket" type issue at this point. It is something that academicians and politicians worry about.

Are there any other comments or questions? Mr. Dymally?

Mr. Dymally. Thank you very much, Mr. Chairman.

Dr. Rhodes, I just have one question: I note from the witnesses here, they all come from the big ones. I don't see Slippery Rock State Teachers College appearing here today. Do you think that some research funds should go to the State colleges, State universities that are involved mostly with teacher training and social sciences, et cetera?

Dr. Rhodes. Mr. Chairman, I had the privilege of appearing about 3 weeks ago with the presidents of various smaller colleges to talk about the Federal role in undergraduate financial aid, and we have a common bond there.

I do not believe that you would serve our best national interests by dividing up the very scarce research funding that we have and giving every one of our 3,000 colleges a slice of the pie. I think if you do that, you will really impoverish the smaller number of universities on which our national progress in research depends. That is a hard statement, but I don't believe that every one of our 3,000 colleges is destined to become a major research university. There is simply no way we can support that.

What we have to do, I think, is to assure that each one of the 3,000 is excellent at the thing that it regards as its chief goal, and Slippery Rock is indeed excellent in what it does.

Mr. Dymally. Well, you take the case of child development and early childhood education—and I regret I missed my friend, Dr. Young, here. The University of California no longer wants to be involved in teacher training. Who does the research for young children, so that we can be able to train teachers?

Dr. **Rhodes**. I would come back to what I said a little earlier, which is, I think you've got to treat applications for research funding strictly on their merits. If Slippery Rock presents the best proposal for research in that field, I would fund it without any hesitation at all. To go on its merits means that it would have an equal chance with the distinguished faculty at UCLA.

Mr. **Dymally**. OK. Thank you very much.

Mr. **MacKay**. Dr. Rhodes, on behalf of the committee, we very much appreciate the effort that you have made. Your written statement will be filed as part of this record.

If there are no other questions or comments, we are adjourned. Thank you very much.

Mr. **Rhodes** Thank you, sir.

[Whereupon, at 11:52 a.m., the committee recessed, to reconvene at the call of the Chair.]

APPENDIX

Testimony of

John R. Silber
President, Boston University

before the

House Committee on Science and Technology

May 8, 1984

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Chairman Fuqua, Representative Winn, members of the Committee. I am grateful for the opportunity to testify today.

The nation is facing a crisis on its campuses. Now, I know that you have heard this claim as often as the neighbors of the boy who cried "Wolf" heard "Wolf, wolf!" On this occasion, however, the alarm is genuine, for I am talking about the crisis in infrastructure that limits our ability to educate scientists and engineers. I shall not occupy the Committee's time by arguing that this country has a desperate need for more scientists and engineers and for more teachers of science and engineering and for more research in these fields. The acts of recent Congresses prove that the Congress is as aware of this fact as any group of Americans, and much more aware than most.

The crisis of which I speak relates to the ability of our colleges and universities to provide the physical facilities in which to educate scientists and engineers and to carry on research in these fields: classrooms and laboratories. These facilities are different in kind from those needed to educate the great majority of students. Science and engineering buildings require increasingly complex and expensive equipment, and because that equipment is itself highly specialized, the buildings themselves must be specialized. Scientific and engineering equipment is, for one thing, often very heavy. The buildings that house it must have floors capable of bearing immense weight. Moreover, such equipment usually requires a carefully controlled environment: controlled in its temperature, its air carefully filtered. The buildings needed for scientific and engineering research and instruction, are, in short, expensive. They are becoming more so as science and technology advances.

Moreover, the rapid pace of technological change means that new equipment can become obsolescent in a year, and obsolete in three. Buildings themselves can become obsolete in a decade.

The need for more scientists and engineers, coupled with the increasing cost of scientific and engineering education, means that colleges and universities are faced with heavy calls for new capital just as they are facing an uncertain future because of declining enrollments which have inevitably followed the falling birth rate of the late 1960s and 1970s. They face increasing difficulty in maintaining their technological infrastructure because of the non-profit nature of their operations. A private business faced with the need to upgrade its physical facilities has at least the possibility of financing construction by borrowing against future profits. But colleges and universities do not make profits; when financially successful, all they do is to avoid deficits. Moreover, they do not, on the whole, price their product in keeping with its cost; students at a given university typically pay the same tuition whether they study liberal arts, fine arts, science or engineering, although the cost of these programs varies enormously; the principal exception to this rule is medical education, where tuition in the independent medical schools is substantially higher. This is necessary because medical education is extremely expensive and possible because physicians are very well paid. On our campuses, heavy and necessary investment in technological infrastructure cannot therefore be recovered from an increased tuition income generated by the students it helps to educate.

It is no wonder, therefore, that higher education is having trouble as a whole in financing the scientific and technological infrastructure that the nation desperately needs. It has been estimated that colleges and universities can finance out of their own resources no more than half the investment in technological infrastructure needed if we are to be able the educate the scientists and engineers our country must have. The difficulty is not, however, evenly distributed. We are divided into haves and have-nots. A comparative handful of major universities--in both the independent and state sectors--are immensely rich. The rich independent institutions have endowments upwards of $60,000 per student. In the independent sector, which comprises 1500 institutions, a mere 35 have approximately 90% of the total endowment. The rich state institutions are located in affluent states of which they are the pride and joy, and can count on generous funding from the taxpayer. A few of them also have very large endowments.

Moreover, all of these rich schools engage in major fund-raising drives, at which they are extremely successful. The Council for the Advancment of Education, which produces a respected annual survey of educational philanthropy, reports that in recent years 20 universities--representing less than 3% of the number surveyed, and less than 1% of all colleges and universities--have received a third of all voluntary giving to colleges and universities. In the academy as perhaps nowhere else, we find honored the Biblical injunction that to those that have, shall be given.

If such "have" institutions can be said to have financial problems, these are more accurately called management problems, and they would be considered financial solutions at the "have not" institutions.

The "have-not" institutions face the most serious part of the problem, for they have the smallest financial base from which to invest. This is not, I should emphasize, because they lack academic quality or commitment to educating scientists and engineers. To the contrary. Let me take Boston University as an example of a have-not institution. We acknowledge that status because, even though our endowment ranks approximately 60th among independent universities in terms of total dollars, we are a very large university, and our endowment is spread out over nearly 30,000 students. We have, therefore, about $3,000 per student, which gives us no more than $300 a year in endowment income per student--a derisory sum. Despite this limitation on our resources, our College of Engineering has, since 1970, increased its enrollment from a little over 200 to nearly 2000. Moreover, while undertaking this major expansion, it has opened careers in engineering to women and minorities to an extent hardly equalled elsewhere in the country: in

1983-84, 24% of its students were women, and 6% were black, proportions far exceeding the national average.

Around the country, there are dozens of other have-not universities with a similar commitment to the education of engineers and scientists. Like Boston University, they have extended themselves to the breaking point in the interests of technological education for the nation. If, in an era of declining enrollments, which nationally will, by 1992, be 25% lower, these institutions are required to make the full investment required in infrastructure by themselves, many will go bankrupt.

We have at the top of the economic pyramid between 20 and 35 educational institutions of great excellence whose wealth matches that excellence. They have massive endowments, access to the purse of the state taxpayer, sometimes both. Because they are universally perceived as excellent, they have great natural advantages in fund-raising and draw on the philanthropic pool all out proportion to the number of students they educate or the magnitude of their contribution to the needs of the country. Last year, the ten schools most successful in fund-raising received 13% of all voluntary giving. They educated about 1.3% of all the students in the country. When we get down to the schools that do not figure in such lists of success with the philanthropists, we discover that the overwhelming majority of all students must depend on less than half of the voluntary support.

But below the 20 to 35 schools at the top of the pyramid, we find perhaps 50 institutions of high excellence but inadequate support. On an inadequate financial base, they educate a larger proportion of students than their richer sisters. These schools are facing needs in construction for technological education that average perhaps $75 million each. They represent a total need of $3.75 billion. This is a very conservative estimate: the University of California has estimated its need alone at $3 billion.

In the case of one group of these "have not" institutions, the urban universities, the challenge is even greater. They are usually physically located in declining or decaying neighborhoods. Often, whatever their own problems, urban universities are physically better off than their neighbors. This in fact represents an opportunity, for by upgrading the infrastructure of the urban universities, we can also upgrade the neighborhoods around them.

Urban universities are committed to the cities in which they live to a greater extent than other enterprises. An urban college or university cannot, in most cases, even consider pulling up its stakes and moving to the suburbs or the sun belt. It is a permanent resident of its city and it will rise or fall with its city. Let me illustrate from the experience of my own institution. Boston University is located on the edge of downtown Boston. Our eastern gateway is located in Kenmore Square, which was once a center of luxurious hotels and major auto dealerships. In recent decades, Kenmore Square has been in sharp decline. We have been concerned at the University to reverse this trend.

We are implementing our concern through the development of our new Science and Engineering Center. A major portion of this project is being built through the total reconstruction of three decaying buildings on the edge of the Square, which, largely vacant, had come to house among other marginal businesses a disco which provided a sanctuary for the drug trade and for criminal suspects fleeing from the police. As a result of our activity, a major structure housing classrooms, laboratories and offices has replaced a pesthole.

Moreover, as the entire Center is completed, we hope that a variety of high-tech businesses will locate their operations in other buildings around Kenmore Square. When this process has been completed, the decline of the area will have been not merely arrested, but reversed; the City of Boston will have gained major additions to its tax rolls, and--the principal end of the project--the nation will have gained a major new source of scientists and engineers, a center for research in these fields, and a forum for consultation at the cutting edge of computer technology and science.

The "have-not" institutions are crucial to the solution of our need for scientific research and scientists and engineers. Even if the handful of "have" universities were to monopolize the entire pool of philanthropic and government support, their capacity for enrollment is not adequate to meet the need.

It is obvious that the federal government should not be asked to solve the crisis in infrastructure by itself. The crisis can be met effectively by a partnership. The educational institutions concerned must, first of all, stretch their own resources to the limit. They are, after all, one of the principal beneficiaries of new facilities. I can assure you that at Boston University we have been pushing our investment in science and engineering to the limit. The state governments, whose economies will also benefit, must also help. And private industry, which benefits as directly as any member of the partnership, must contribute. At Boston University, we have been fortunate in receiving millions of dollars for our Science Center from such corporations as Digital Equipment, IBM, Data General, and the John Hancock Mutual Insurance Company. This last gift is notable in coming from a company that is not directly concerned with science and engineering, but which understands what our Science Center will mean to the nation as a whole and to Kenmore Square in Boston.

But the federal government should regard the nation's technological infrastructure with the same attention it has paid our transportation infrastructure. The laboratories and classrooms needed for education and research in science and engineering are a national need at least as important as our highways and bridges. In some ways, they are more important, because it is from such laboratories and classroom that will come improved methods for building roads and bridges and the economic strength to pay for them. Our technological infrastructure is, if anything, even more basic than our transportation infrastructure.

It is time for the federal government to redress the present imbalance in funding for science and engineering facilities; to do so would solve an urgent national need. The problem is more complex than the simple provision of an adequate supply of scientists and engineers. As industries move from the rust belt to the sun belt, or from the rust belt out of the country entirely, the importance of research universities in the areas left by industry becomes crucial. People tend to migrate where there are facilities. If the universities of the northeast and the industrial midwest are unable to compete with the rest of the country in the education of scientists and engineers, and in the conduct of scientific and technological research, their areas will undergo further decline.

As we consider federal funding for this purpose, it is essential that we realize that our nomenclature in describing our system of higher education is likely to mislead. We speak of "public" and "private" colleges and universities, and it is sometimes asked why the taxpayer should subsidize private institutions. But the fact is that the colleges and universities of the independent sector are no more private than those of the state sector. They are open to the public, educate the members of the public, and conduct research in the public interest. Thus far, federal legislation on higher education has been admirably free of any confusion on this matter. Let us keep it so.

An adequately funded program of grants for laboratory and classroom construction would be a major opportunity for the Congress to invest tax dollars in a manner that would guarantee the taxpayers a generous return on their investment. Long after the youngest member of the 98th Congress has retired from public life, discoveries made in the laboratories and classrooms such a program would fund would continue to advance the prosperity and security of the United States and its citizens.

Such a program requires innovative machinery for its administration. The resources necessary to conduct research and education in science and technology at the cutting edge should not be limited to a few institutions that developed major research abilities in the 1950s. Any major new federal program of support for science and engineering facilities ought to be precisely targetted on those institutions that have shown their commitment to and ability in these areas, as well as financial need. There needs to be a comprehensive review of the national inventory of educational excellence and the national inventory of educational need. When this has been accomplished, a funding mechanism should be obvious.

I spoke at the beginning of a crisis. The crisis in technological infrastructure facing our universities is one of those crises for which the solution is apparent and ready to hand. I hope the Congress will move with all deliberate speed to help us solve it.

The
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May 7, 1984

Congressman David McCurdy
Cannon Building, Room 313
Washington, D.C. 20515

Dear Dave:

Your staff called for comments on three issues which are to be considered in hearings on Tuesday. I'll attempt to address each of them as all three are of critical importance to the research community. The first is a concern with regard to facilities. Clearly, in the decade ahead much of the progress which is going to be made in the science arena is going to be accomplished by interdisciplinary teams. One of the major problems we face on university campuses is finding space which makes it possible for these interdisciplinary teams to be housed together. The success of interdisciplinary teams depends very critically on their ability to interact on a daily, informal as well as formal basis. This can only be accomplished if they are physically housed together. The problem is that virtually no institution has space which can be assigned to interdisciplinary teams on an as-needed basis. Research space is always at a premium and one of the truisms in research is that it will fill up the space available. It is extremely difficult to obtain funding from alumni for space which is not the province of a specific department or college, but rather is to be made available on an as-needed basis to interdisciplinary teams. The problem is a general one faced on virtually every campus which is concerned centrally with research. I would strongly urge that attention to this problem be given in any proposed legislation. Our experience confirms the reality of this problem at the University of Oklahoma in the assignment of space for the Energy Center. In practice it is extremely difficult to retain space for assignment to these kinds of interdisciplinary teams. I sincerely hope that this issue will be seriously considered by your committee.

The use of the peer review system in the allocation of resources whether these be for research or facilities is absolutely essential if we wish to ensure quality issues are primary in the decision process. I have served as a member of peer review panels at the national, state, and university level for many years. Clearly, the process is not without problems but it is far and away the best means available of insuring that only quality issues are considered. I think it is one of the primary factors which is responsible for the quality of science in our nation. Much of this credit has to be given to those political figures and civil servants who fully appreciated the essential need for separation of the award of funding for science from political considerations. I strongly encourage the use of peer review in any process which seeks to allocate funds for research or facilities if quality is to be their primary consideration. In my judgement, only if quality issues are central to the decision making process are we as a nation likely to maintain our stature and position within the world community.

The issue of indirect cost in research is a complex one. It is extremely difficult to compare indirect cost rates across the country as what one university may include as direct costs, another may include as indirect costs. However, it is clear that the indirect costs of doing research seem to have increased at a more rapid rate than have the direct costs. Many faculty and administrators do not understand indirect costs and view them with considerable suspicion. The federal government has also shared in that suspicion and has insisted on more and more elaborate record keeping devices. These in turn add to the costs of doing research and to the indirect costs which must be charged. There does not seem to be any simple solution to the indirect cost issue but it is important to realize that they are, in most cases, legitimate costs of doing research on our campuses. I would urge a careful study of this issue as I think it is one which is important to the research arena. Universities in financially difficult times such as the present find it increasingly difficult to both share in the costs of the research through the cost sharing mechanisms which have been established and to face the possibility of reduced funding for the costs which are indirectly associated with the research. I share the concern of those who view with alarm the increase in costs associated indirectly with research. At the same time I think it is important to realize that arbitrarily reducing these costs or setting a limit on these costs is not likely to adequately respond to the complexity of the problem. One always hates to urge that additional study be done but I think this is a case in which that is the most appropriate course of action.

I am pleased to be able to provide you with this information and hope that you will feel free to call on me in the future if you need testimony or information on issues such as this. Best regards.

Sincerely,

Kenneth L. Hoving
Vice Provost for Research Administration
and Dean of the Graduate College

KLH:pg

The
University of Oklahoma

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(405) 325-2621

May 7, 1984

The Honorable David McCurdy
313 Cannon HOB
Washington, D. C. 20515

Dear Dave:

I am pleased to be able to comment on the hearings being held by the Science and Technology Committee on the nation's science and engineering infrastructure. It is encouraging to see the Congress hold these hearings. Despite the central role of science and engineering in fostering economic growth and ensuring our national security, the infrastructure to support these activities has several weaknesses. I wish to focus my remarks on the problem of inadequate support for facilities and laboratory equipment, which has special meaning for our nation's engineering schools.

The problems of deteriorating college physical plants, inadequate or obsolete equipment, and equipment that is not commensurate with technological advances in the world today are too widespread to be ignored. These deficiencies have led to a significant decline in the quality of our nation's engineering educational programs. Over the past ten years, the percentage of engineering programs receiving the maximum six-year accreditation from the Accreditation Board for Engineering and Technology has fallen from fifty-eight percent to thirty-five percent, a stark verification of the pattern so many of us in education sensed intuitively. The Association of American Universities estimates the average age of research equipment in universities is twice that of industry. The development of computer science and computer-based technologies is stunted because of the widespread lack of availability of modern computers at unversities. Today, many of our students are being educated on equipment that is older than the students.

It is no accident that these problems have arisen in a time when federal support for education, particularly science and engineering education, has waned. While the federal research and development budget has grown, much of this is targeted for defense, with rather little for education. Recent efforts to address the research instrumentation problem by the Department of Defense and National Science Foundation notwithstanding, support for educational facilities and equipment, including computers, is pitifully inadequate. The elimination of the NSF program of support for instructional equipment is symptomatic of these trends.

An estimate of the magnitude of the problem can be obtained by using the recommendation of the Florida Engineering Deans, and others, that an annual expenditure of $400 per full-time equivalent engineering student would provide sufficient resources over several years to ensure an adequate laboratory experience for students. If the same estimate is used for both science and engineering students, we then estimate $480 million is required annually to provide for the educational equipment needs of our nation's science and engineering students. I would urge consideration of a federal program of support required annually to provide for the educational equipment needs of our nation's science and engineering students. I would urge consideration of a federal program of support for science and engineering education which would provide matching funds to institutions of higher education for the purpose of improving the facilities and equipment available for them. Our estimates suggest a $240 million annual budget would accomplish this purpose.

I would hope these brief remarks are helpful. Please call on me if you need additional information.

Very truly yours,

Martin

Martin C. Jischke
Dean

MCJ/cjr